THE WEEK'S EVENTS

Middle-Income Housing Under Discussion

President and FHA adviser discuss plans for housing at $5-$10 per room per month

Methods to meet the housing needs of the group which cannot afford to purchase homes with FHA financing and which is not eligible for the low-cost subsidized housing which will be provided by the U. S. Housing Authority were under discussion on two fronts last week. The President, at a press conference, said that there is a group falling between the fields of the two agencies which need housing at a rental of $5 to $10 per room per month and that an attempt is being made to find means for cheaper financing of housing for that group.

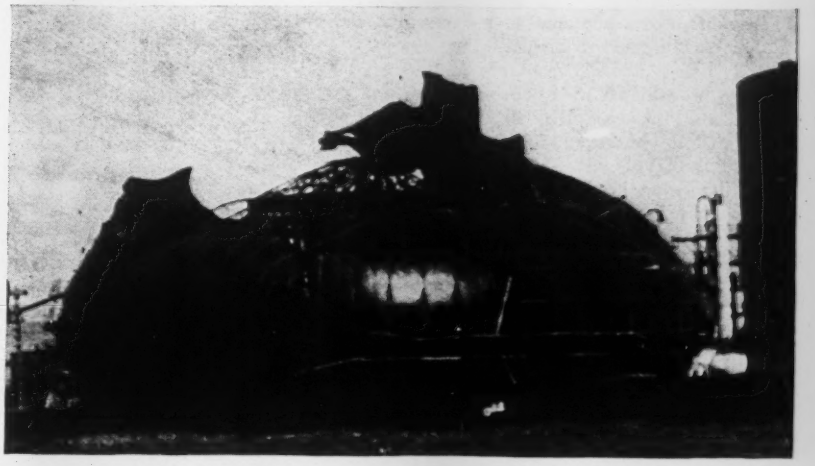
There is a definite national need, he said, for individual houses that can be built for $3,000 and rent for $5 to $10 a room. Consideration is being given to some such means as tax exemption to draw on the funds of small investors who want investments at 3 to 3½ per cent.

Lambert's plan

The next day, Nov. 2, Gerard B. Lambert, adviser to the FHA, proposed that the cost of rental projects in this price range be reduced by eliminating profits necessitated by speculative construction. Lambert has experimented with his idea by using his own money in cooperation with the Princton, N. J., Housing Authority to construct a $60,000 project.

Lambert suggested that projects be financed by issuing securities which would pay a fixed return each year until, after the principal with fair interest had been repaid, the properties would automatically revert to the municipalities where they were located. He said that the chief problem at present is to provide an incentive for investors. It might be possible, he said, to finance such buildings by tax exempt securities issued by housing authorities. It might also be possible, he said, to offer reductions in individual surtax assessments equal to the amount of money invested in such projects.

Lambert said that the program he proposed would not require new legislation or creation of new types of tax exempt securities.



BAD WELD BELIEVED CAUSE OF TANK FAILURE

FAILURE on Sept. 21 of an 80,000-bbl. spheroidal gasoline tank at Sarnia, Ont., is attributed, in a statement issued by the Chicago Bridge & Iron Co., to the fact that at the outer top node, although the plates were properly joined, there was no fusion into the top flange of the girder for a distance of 3 or 4 ft. The tank was built for Imperial Oil Co. by Horton Steel Works, Ltd., Canadian subsidiary of Chicago Bridge & Iron.

The statement issued by president George T. Horton of Chicago Bridge & Iron said that "it is easy to see now that a different detail, enabling us to cut inspection plugs from the particular weld, would have been better construction . . . but the fact remains that had we had even a most indifferent weld at the point in question, no accident would have occurred."

The tank was 127.1 ft. in outside diameter and 40 ft. deep. It was designed to withstand an internal pressure of 15 lb. per sq.in. on the basis of a working stress in the steel of 11,000 lb. per sq.in. It was of welded construction. At the time of the failure, the tank was still undergoing tests and had not yet been turned over to the oil company. For about 38 hours before the tank failed, it had contained 14.7 ft. of water and was under 15 lb. air pressure. As far as is known no change in these conditions preceded the break.

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Nebraska Power Project Readjusts Allotment

One Nebraska power and irrigation project has received an increase in its PWA allotment and, because of the limited funds available for the state, a second project has had its allotment reduced.

The allotment for the Central Nebraska District has been increased by $5,890,000, of which $3,240,000 is a loan and $2,650,000 a grant. Previous allotments to this project amounted to $15,553,000 as loans and $13,543,000 in grants.

A previous allotment of $5,190,000 to the Loup River District has been reduced to $1,800,000. The original allotment was for construction of certain primary and secondary transmission lines, but it was found that the reduced allotment would be sufficient to allow the system to meet minimum requirements.

The new allotment for the Central Nebraska project will cover construction of a supply canal from the inlet of the Johnson regulating reservoir to the main irrigation canal, the construction of Johnson Canyon power houses Nos. 1 and 2, and of a connecting transmission line.

Pontoon Bridge Bids Called This Month

Toll bridge authority will spend seven million on floating bridge and tunnel approach

The Washington State Toll Bridge Authority will open bids Nov. 29 for construction of a pontoon bridge across Lake Washington at Seattle. The authority has $7,200,000 available for the project, of which $3,741,000 is a PWA grant and the rest will be provided through sale of revenue bonds to be retired from tolls.

Major items in the project are the pontoon bridge itself, 6,561 ft. long; a 1,445-ft. twin-bore tunnel through Mt. Baker Ridge at the Seattle approach to the bridge; and a reinforced concrete viaduct 2,578 ft: long over Mercer Slough on the east side of Lake Washington.

Concrete pontoons

The reinforced concrete pontoons for the bridge will each be 59 ft. wide, 14.5 ft. deep, and 350 ft. long, containing numerous crosswise bulkheads. They will be built at convenient points on the lake, floated into position and anchored. A 200-ft. draw span will consist of a floating pontoon which can be slid into a slot in the bridge between the two traffic lanes. The roadbed of the bridge will be 7 ft. above the water level of the lake.

The approach tunnel will be a twin-bore structure, each tube carrying a 24-ft. roadway and a 3-ft. sidewalk. The cost of the bridge proper is estimated at $2,500,000, of the tunnel at $1,000,000, and of the east approach viaduct at $700,000.

The Lake Washington bridge project is the first half to be constructed of a new highway into Seattle from the east. The second half of the project, which it is understood will be begun next year, will consist of 22 miles of four-lane concrete pavement to be built on a new alignment from Mercer Slough to Issaquah. This section will be built with regular state highway funds according to present plans.

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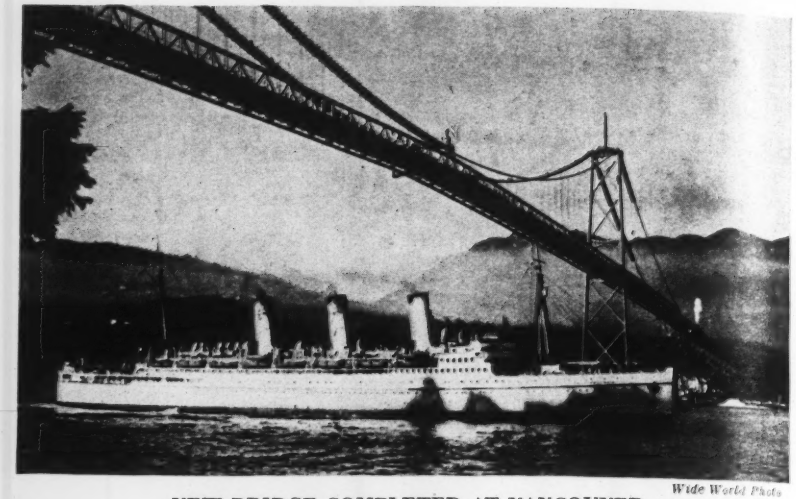
Cairo Bridge Opened Four Months Late

A new bridge across the Ohio River is to be dedicated at Cairo, Ill., Nov. 11. Originally scheduled to be held July 1, opening of the highway bridge was held up by delay in completing the new Kentucky state highway from Wycliffe to the bridge. The bridge, according to Modjeski & Masters, engineers on the project, was finished on schedule time; water on the Kentucky flood plain, however, retarded work on the connecting highway and traffic could not reach the completed structure until this month.

The new Cairo bridge is 5,865 ft. long and contains three main river spans of 800, 650, and 650 ft., respectively. It consists of a series of alternating cantilever and anchor arms for three spans with a suspended span only in the long opening. The bridge was described in an *Engineering News-Record* article in the issue of June 30, 1938, p. 901.



Wide World Photo

NEW BRIDGE COMPLETED AT VANCOUVER

THE LIONS GATE BRIDGE across the First Narrows at Vancouver will be opened to traffic this month, although formal dedication will be deferred until next summer. The $6,000,000 suspension bridge has a main span of 1,550 ft. and two side spans of 615 ft. In addition there is a 3,000-ft. approach on the north shore. With a vertical clearance of 200 ft., the bridge will carry a 29 ft. roadway and two 5-ft. sidewalks.

The superstructure of the bridge was erected by the Dominion Bridge Co. and the Hamilton Bridge Co., while the substructure and road work were awarded to Stuart Cameron & Co. and the Atlas Construction Co. Monsarrat & Pratley were designing engineers on the project. The bridge was financed by a British syndicate and will be operated as a toll structure; the syndicate is interested in real estate across the bay.

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Harrington Will Head Chicago Transit Body

The city council of Chicago has created a department of subways and traction charged with the building of the city's new PWA-financed $40,000,000 subway system and the drafting of a traction unification ordinance. Later, the new department will supervise and maintain the subways and build additional lines.

The commissioner of the new department is Philip Harrington. A graduate in 1906 of Armour Institute of Technology, Harrington was with the Sanitary District of Chicago for 29 years. For ten years of that time he was assistant chief engineer and for three years chief engineer. During the recent discussion of the new subway program, Harrington has been acting as consultant to the city council.

PHILIP HARRINGTON
New Transit Commissioner in Chicago

Thirty-Two Million More Loaned by USHA

Additional loans to housing authorities in eight cities totaling $32,632,000 were announced Nov. 4 by the U. S. Housing Authority. Approval of these loans, which will finance fifteen low-rent housing projects, brings to $265,054,000 the total of loan contracts which have been signed by USHA.

Largest of the new loan contracts is one for $16,924,000 to finance a housing development in Boston. Among the other contracts are $5,541,000 for Memphis, $3,960,000 for Buffalo, and $2,429,000 for Trenton. The loans provide for four construction projects in Boston and two each in Trenton, Memphis, Pensacola and Wilmington.

Signing of the present loan contracts means that USHA has now contracted for one-third of its authorized $800,000,000 in loans. Contracts signed so far provide for construction of 52,951 family dwellings to re-house more than 211,000 people. In addition, $311,050,000 of USHA funds have been earmarked for specific cities.

City-Federal Housing For New York

Mayor announces plan for a federal and a city housing project in lower East Side Manhattan

Tentative plans for two new housing projects to be erected side by side somewhere in the lower East Side of Manhattan have been announced by Mayor LaGuardia of New York. One would be a $12,000,000 USHA-financed project and the other a $7,500,000 project to be financed by the city, presumably from the proceeds of the new occupancy tax which was established this year to provide funds to guarantee municipal housing bonds.

The mayor's announcement followed a conference between the mayor, New York City housing commissioner Rheinstein, USHA Administrator Straus and Senator Wagner of New York. At this conference, the mayor said, an agreement was reached "through the good offices of Senator Wagner" by which the USHA policy of limiting land cost to $1.50 per sq.ft. was "adjusted" to permit purchase of land in a Manhattan slum area. The nature of the adjustment was not made public.

Queensbridge contract

Low-cost housing took another step forward in New York City as Administrator Straus approved the $8,242,000 bid submitted by Cauldwell Wingate Co. of New York City for construction of the Queensbridge project. The construction bid did not include improvement of the site and landscaping, elevators, or household equipment. On the basis of the figures now in hand, the cost per room and per unit in the Queensbridge development will be considerably below the limitations imposed by Congress, Straus said.

Since the George A. Fuller Construction Co. now has construction well under way on the Red Hook project, the entire $30,000,000 housing program for New York City is going rapidly forward.

Jacksonville contract approved

USHA has also approved a bid submitted to the Jacksonville Housing Authority for construction of 40 buildings, all row houses, comprising the housing project there. The base bid approved for the 230 living quarters was submitted by J. A. Jones Construction Co. of Charlotte, N. C. and amounted to $650,000. On the basis of bids so far approved, the construction cost per dwelling unit will be about $2,600 and cost per room will be about $600.

CONTRACTS AND CAPITAL

ENGINEERING construction awards for the short week due to the Election Day holiday total $37,260,000, a gain of 4 per cent over the corresponding week in 1937.

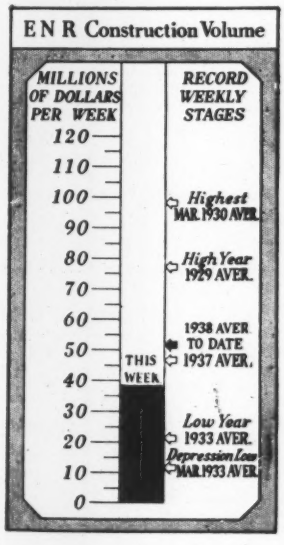
Construction awards for 1938 to date, $2,343,931,000, are 10 per cent above the $2,131,356,000 reported for the 45-week period a year ago.

Public construction is 48 per cent higher than in the 1937 week, but private awards are 63 per cent lower.

In the classified construction groups, public buildings, streets and roads, earthwork and drainage, waterworks, and unclassified construction are higher than their respective volumes a year ago. Public building and street and road volumes total $23,817,000 for the week, and make up almost two-thirds of the current total.

New capital for construction purposes for the week totals $79,353,000, an increase of 1142 per cent above the 1937 week. The total is made up of $32,632,000 in USHA loans, $16,728,000 in state and municipal bonds, $14,351,000 in corporate security issues, $9,486,000 in REA loans, $5,890,000 in PWA allotments for non-federal projects, $50,000 in PWA allotments for federal projects, and $216,000 in RFC loans.

New financing for 45 weeks of 1938 totals $3,491,107,000, an increase of 67 per cent over the volume for the corresponding period last year.



CONTRACTS

(Thousands of dollars)

	Week Ending Nov. 11 1937	Nov. 3 1938	Nov. 10 1938
Federal	$731	$9,262	$5,803
State & Municipal	20,858	44,085	26,149
Total public	$21,589	$53,347	$31,952
Total private	14,331	17,666	5,308
TOTALS	$35,920	$71,013	$37,260
Cumulative 1938 (45 weeks)			$2,343,931
1937 (45 weeks)			$2,131,356

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1937 45 Wk.	1938 45 Wk.
NON-FEDERAL	$1,340,584	$2,347,412
Corporate securities	489,758	349,932
State & Mun. bonds	442,761	548,961
PWA loans, grants	178,126	814,126
RFC loans	29,939	100,344
U.S.H.A. loans	.....	265,054
R.E.A. loans	.....	67,495
Federal Aid-highways	200,000	201,500
FEDERAL	$746,223	$1,143,695
TOTAL CAPITAL	$2,086,807	$3,491,107

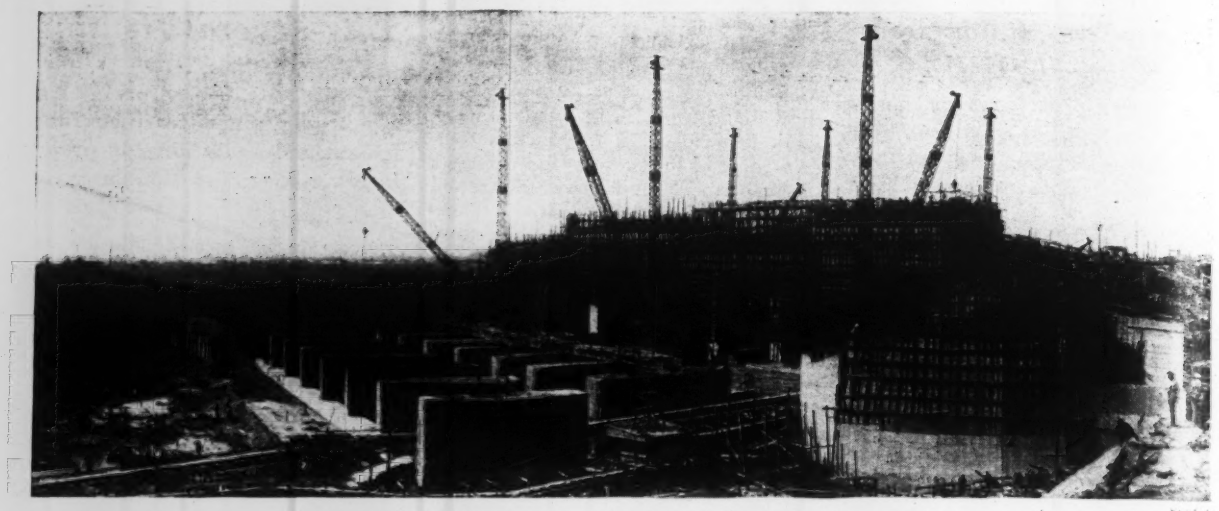
FHA MORTGAGES

	Nov. 4 1937	Oct. 29 1938	Nov. 5 1938
Selected for appraisal	$9,138	$23,645	$21,229*
Cumulative 1938 (44 weeks)			$864,076
1937 (44 weeks)			$528,964

* Subject to revision.

ENR INDEX NUMBERS

Index Base		1913	1926
Construction Cost	Nov.	234.40	112.69
Building Cost	Nov.	195.58	105.71
Volume	Oct.	217	95



RUSSIANS DEVELOP VOLGA FOR POWER AND NAVIGATION

CONSTRUCTION is now under way on two of the three power plants included in the initial project for the development of the Volga River by the Soviet government. Shown above is work on Dam. No. 2 of the Rybinsk power station, which will have a capacity of about 200,000 kw. The Uglich station, a 100,000-kw. project, is also under construction, and early work is planned on the smaller Ivankovo plant, which will generate about 30,000 kw.

Next step in the Volga project will involve four more dams with an annual output of about 16,000,000,000 kw.-hr. The final capacity of the system is expected to be 50 or 60 billion kilowatt-hours per year.

In addition to the generation of power, the Volga project contemplates creation of a navigable waterway along the whole length of the Volga and Kama rivers and the use of surplus water for irrigation by pumping.

Flood Control Work Starts Soon in New England

A recent report of the New England Regional Planning Coommission on flood control construction projects in the New England section discloses plans for winter construction to be carried out at once. Brigadier General John J. Kingman, acting chief of army engineers, has reported, in part, as follows:

"The Flood Control Act approved June 22, 1936, authorized for the Merrimac River Valley the construction of a system of flood control reservoirs, at an estimated construction cost of $7,725,000 and for the Connecticut River basin a reservoir system at an estimated construction cost of $10,058,900. This act prescribed certain conditions of local cooperation, including acquisition of land at local expense. The Flood Control Act approved June 28, 1938, added to the authority the construction of seven local protective projects for the more heavily populated centers along the main stream at an estimated cost of $11,524,000. This act also removed the requirement of local cooperation for reservoir projects, so that the reservoir lands must now be procured by the United States and the reservoirs maintained and operated by the United States after construction.

"Funds for the initiation of the projects were not included in the budget for fiscal year of 1939 as need therefor could not be foreseen prior to the passage of the last flood control act. However, the president's recent instructions caused the department to make allocation of $4,750,000, these funds being secured in greater part by revoking from other projects such amounts as could be spared without serious detriment to the work.

"Plans for the Knightsville, Mass., Surry Mountain, N. H., and Union Village, Vt., reservoirs, all in the Connecticut River Valley, and the Franklin Falls Reservoir, N. H., in the Merrimac River Basin, are complete and it is expected the land acquisition and dam construction at these sites will be begun in the immediate future.

"Allotment has also been made for the initiation of land acquisition and dam construction of the Birch Hill Reservoir in Massachusetts in the Connecticut River basin and the Riverhill Reservoir, N. H., in the Merrimac River Valley. Plans for these latter two reservoirs are not complete, but are being prosecuted vigorously in order that construction may be placed under way prior to the end of the fiscal year.

"The protective works for Hartford and East Hartford, Conn.; Springfield, Chicopee, Northampton and Holyoke, Mass., on the Connecticut River, are being undertaken with Works Progress Administration and Public Works Administration funds now in process of allotment. Work on all will be prosecuted vigorously."

Engineering Council Plans Forum and Convention

The first four sessions of the annual assembly of the American Engineering Council, to be held in Washington Jan. 12–14, will be conducted as the third of the series of forums on public questions which are being held under the sponsorship of the American Engineering Council. The fifth and sixth sessions will include the annual all-engineer dinner and a business session.

Topics planned for discussion at the forum session include: The economic status of the engineer, engineering factors in the size of business, public and private construction in relation to the engineer, national planning in relation to the engineer.

A forum was held in May on employment, and another is scheduled for Nov. 11 on inventions.

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Potomac Valley Pollution

Formation of a Potomac Valley conservancy district to deal with stream pollution problems of the Potomac River and its tributaries will be proposed to the governments of the District of Columbia, Maryland, Virginia, West Virginia and Pennsylvania as the result of favorable action on the proposal by the Potomac Valley Pollution Conference.

Second Incinerator Closed in Detroit

City will bury most of its garbage, keeping two incinerators in operation

A few weeks after shutting down the Northwestern incinerator plant in Detroit (*ENR*, Oct. 20, 1938, p. 477), the city has shut down another incinerator, the St. Jean plant. Garbage and rubbish which has been routed to the St. Jean plant will be buried and covered.

"I don't think we'll ever open up the Northwest incinerator again," Commissioner of Public Works Henry E. Beyster announced. "It is purely a dollars and cents proposition, not simply because of protests from residents of that vicinity. It costs us only about 70 cents a ton to bury garbage as compared to more than $2 a ton to burn it in the Northwest plant." The commissioner explained that the cost differential did not apply to the two remaining incinerator plants in the city because they are centrally located and only short hauls are involved.

At present, the commissioner said, the city is collecting about 840 tons of garbage per day and burying about 400 tons of it, burning the rest. He expects to continue burying garbage until frost sets in and then burn it all in the two incinerators still working, which have a combined capacity of 600 tons a day; he expects collections to be reduced during the cold weather.

The Northwestern plant, shut down last month, was the first to be completed of three PWA-financed incinerators being built under a $1,458,000 program. The commissioner attributed the increase in incineration cost over that anticipated to the fact that the city is not collecting as much combustible rubbish as was expected and has been forced to buy additional coal for the incinerators.

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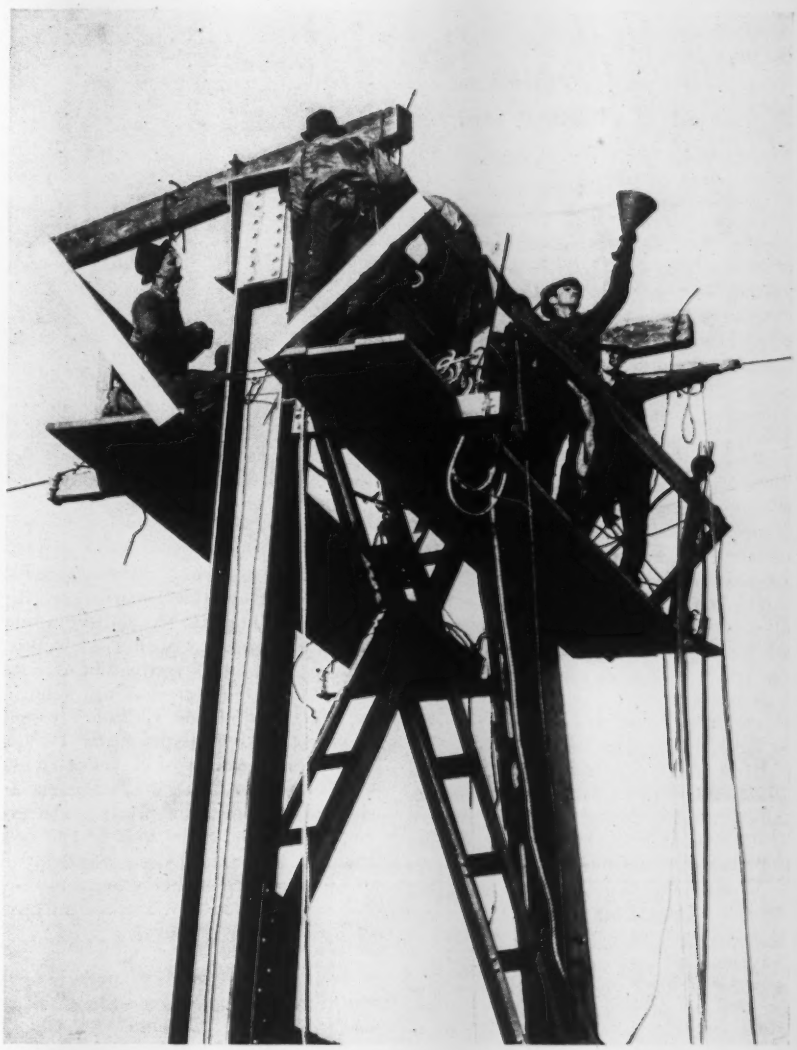
Steel Wage Proposed Under Walsh-Healey Act

A minimum wage of $.625 per hour in most of the country and $.45 per hour in twelve southern states would be required in steel plants making goods for the government under a scale proposed Nov. 5 by Secretary of Labor Perkins on the recommendation of Chairman Thomas Holland of the Public Contracts Board. Hearings will be held on this proposal.

Under the Walsh-Healey act, manufacturers selling to the federal government must maintain prevailing standards of wages and hours as determined by the Department of Labor.



STEEL RISES FOR BRIDGE AT SHASTA DAM

PERCHED on a scaffold above the Sacramento River, these workmen are rivoting joints of the center pier for a 512-foot combined railroad and truck bridge being erected just below the Shasta Dam site. The man holding up the funnel is catching a hot rivot tossed from below. This high-level plate girder bridge will provide access between the existing main line railroad on the west bank of the river and the contractor's facilities on the east bank of the Sacramento River.

Heavy construction is under way on several phases of Shasta Dam, a unit of the Central Valley Project being constructed by the United States Bureau of Reclamation.

Telegraph Company Liable For Flood Damage

The Arkansas Supreme Court on Oct. 31 upheld a lower court decision awarding damages to Pulaski County land owners against the Western Union Telegraph Co. The land owners had contended that the telegraph company had weakened the Byrd Levee by placing a telegraph pole on it and that this caused the levee to go out in July of 1932, flooding their land. The company, on the other hand, contended that unprecedented rainfall overtopped the levee and caused it to go out and that there was no evidence of negligence in the setting of the pole.

There was a conflict between the testimony of engineers who had been ordered to make a survey of the area after the flood and eye witnesses introduced by the land owners, who said that water in the bayou never rose higher than the levee. The high court held that in the face of such conflicting testimony it was for the jury to decide which was in error.

Louis C. Hill Dies In California

Alfred H. Marshall designer of Chicago experimental filtration plant dies at 62

Louis Clarence Hill, consulting engineer, Los Angeles, died there Nov. 5 at the age of 73. Hill was a consulting engineer for the United States Bureau of Reclamation and for the State of California, and also served with the Los Angeles Flood Control District. He was a partner in the Los Angeles engineering firm of Quinton, Code-Hill-Leeds & Barnard. After receiving his bachelor's degree in civil engineering in 1886 from the University of Michigan, Hill did some railway work and then returned to school to earn a B.S. in electrical engineering in 1890. The next 13 years were spent on the faculty of the Colorado School of Mines, and from 1903 to 1914 he was with the U. S. Reclamation Service. During this period he was in charge of construction of the Salt River project (including Roosevelt Dam), the Yuma project and projects in New Mexico and Texas.

Hill entered private practice in March 1914, and since that time had been retained frequently by the U. S. Bureau of Reclamation as consultant. Among the more important engineering projects with which he had been connected are Gibralter Dam, Pine Canyon Dam (now Morris Dam), various works for the Los Angeles County Flood Control District, and Sutherland and El Capitan dams for the city of San Diego. He was also consulting engineer on the Yaqui River project in Mexico. He was the American member on the commission for the distribution of the waters of the Rio Grande and the Colorado Rivers and represented the U. S. Bureau of Reclamation as the consulting service on construction of Coolidge Dam on the Gila River in Arizona. More recent projects on which Hill was consulted were: 14 dams in the Muskingum district of Ohio, Conchas dam, Tygart dam, Bluestone dam, Sardis dam, Fort Peck dam, Bonneville dam, Boulder dam, Imperial dam, and on the All American canal. He served as the president of the American Society of Civil Engineers in 1937.

ALFRED H. MARSHALL, an engineer in Chicago water department, died Nov 2 at the age of 62. He was educated at the University of Wisconsin, and his early experience was with Daniel W. Mead. From 1905 to 1915 he was chief design engineer for the Arnold Co. and the W. H. Rosecrans Engineering Co. From 1920 to 1923 he was superintendent of construction for the Shank Engineering Co., building, among other structures, the Hines Memorial Hospital and the Graymere Hotel. He entered the service of the city of Chicago in 1923, making first an elaborate investigation of water supply for the surrounding suburbs. In 1927 he designed Chicago's experimental filtration plant. From 1929 to 1931 he had charge of a section, under the Division of Waterworks Design, designing four filtration plants for a non-metered system. Since 1931 he had been engaged on studies, design and layout of the South Side filter plant for which PWA recently made a 45 per cent grant of $20,900,000.

LOUIS C. HILL

JAMES ELBERT MOODY, for three years consulting engineer to the commissioner of public works, Chicago, died Oct. 23 at the age of 59. At the time of his death he was president of the Illinois Asphalt Co. Moody's early work included service in the Philippines with the U. S. Lighthouse Bureau, contractors superintendent in Seattle, bridge engineer with the sanitary district of Chicago, and chief engineer of the Massey Concrete Products Co.

JACQUES DE TARNOWSKY, 58 year old structural engineer for the building division of the New Orleans architects office during the past ten years, died Oct. 30 in that city. He was a native of France, and began his technical service in the employ of the New Orleans branch of the Virginia Bridge and Iron Works.

IRA CLINTON OTIS, locating engineer for the Washington State Highway Department, died in Seattle, Nov. 2 at the age of 74.

WILLIAM WARREN, 85, pioneer Central Washington civil engineer and railroad construction expert, died Oct. 31 at Yakima. Warren was commissioned by the Russian government 15 years ago to assist in developing Russian railways.

JOHN W. REISS, 47, former Louisville civil engineer, died Nov. 2.

JAMES T. MOORE, an assistant engineer in the Newark, N. J. Sewer Department, died in Elmira, N. Y., Nov. 4 at the age of 54.

ALFRED WEBER, 67, head of the utility division of the Seattle city engineering department a quarter of a century until retiring three years ago, died in Seattle, Oct. 30.

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Consultants Named to Study Aqueduct Water Softening

The Metropolitan Water District of Southern California has retained Charles P. Hoover and James M. Montgomery, consultants, to assist in the preparation of plans and specifications for a water softening and filtering plant which the district may build to treat water from the Colorado River aqueduct.

The board of directors of the district recently granted authority to general manager F. E. Weymouth to retain consultants, but final decision concerning the construction of a plant will be made later by the board, it has been announced.

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Contract Let For Link To Washington Bridge

Contract for construction of the roadway between the Harlem River Speedway and the George Washington Bridge tunnel in New York City has been awarded by The Port of New York Authority to Wood & Hagan for $291,935.30. This is one of the final steps in providing facilities for traffic to move between the bridge plaza and the Harlem River Speedway without crossing any street at grade.

The pending work covers the southerly portion of the connecting link through Highbridge Park. It is part of the plan for an attractive structure through the Park, joining the Harlem River Speedway with the easterly portal of the bridge tunnel at Amsterdam Avenue and 179th Street. The roadway will pass through a masonry arch of the existing Harlem River High Bridge.

The roadway thus established on the east side of Manhattan will be similar to the connection to the West Side Express Highway on the west side of the Island. Twenty-one bids ranging from $291,935.30 to $539,028.85 were received by the Port Authority in making the award. It is being financed with assistance from the Federal Public Works Administration.

COMMENT AND DISCUSSION

Readers' opinions on matters that concern the engineer

Quick-Setting Grout

Sir: I have just read with interest the article by R. L. Price, in your issue of Oct. 20 entitled "Iron Inner Tube Strengthens Conduit".

The part describing the grouting process using a mixture of alumina cement to accelerate rapid setting of the initial grout under the bottom plates excited my interest. Some years ago I had occasion to use "Lumnite" cement on a project requiring the structure to be in service within 24 hours. During subsequent construction employing portland cement the men at the mixer inadvertently mixed a batch using some of the Lumnite remaining on the job. The only reason it was noticed, aside from the difference in color, was the fact that Lumnite batch had set up within the body of the normal pour causing difficulty in spading.

I have been wondering whether the difference in the time of set between portland and alumina cement would render them ineffective for grouting, giving rise to a series of dams, the resultant effect being to impede normal flow of grout. This conjecture of mine is concerned more with grouting behind concrete linings of rock tunnels than with the project described by Mr. Price, success of which is assumed.

Any information as to the compatibility of the cements used for grouting will be appreciated.

RUDOLPH COOK
New York City, Oct. 24, 1938

Answering the question raised by Mr. Cook, J. L. Miner of the Atlas Lumnite Cement Co. states that unless properly used, mixtures of calcium aluminate cement and portland cement will cause difficulties. However, Mr. Miner states that such mixtures have been used successfully on Boulder Dam and other large structures where quick-setting grout is desired, also that the value of such a grout for sealing rock seams, filling joints and shutting off water has been recognized elsewhere.

By the addition of varying quantities of portland cement to calcium aluminate cement, or the addition of calcium aluminate cement to portland cement, the setting of the grout can be greatly accelerated. The addition of some 15 to 30 per cent causes the set to start from 60 to 5 minutes. Results vary slightly with different portland cements. As the mixture approaches the 50-50 ratio, in the range from about 40-60 to 60-40, setting is almost instantaneous. The initial strengths when portland cement is added to calcium aluminate cement are higher than when calcium aluminate cement is added to portland cement.

In using mixtures of the two cements, Mr. Miner states that they should be thoroughly mixed dry so that the two cements will be evenly distributed throughout. Otherwise portions of the mixture will set instantaneously causing difficulty in handling the grout.—EDITORS.

Multiple-Use Reservoirs

Sir: I note a few minor errors in the digest given in the *Engineering News-Record* of Oct. 27, 1938, of my paper, entitled "Results of the Operation of the Sacandaga Reservoir in Regulating the Hudson River", presented at the meeting of the American Society of Civil Engineers at Rochester on Oct. 12.

Your summary quotes me as saying, "that the annual average rainfall is 27.6 in." This should be "the annual average runoff". The mean annual rainfall of the Sacandaga watershed is about 50 in. Again your article states, "Power companies pay for the use of the water but there are no restrictions on the board as to release of water". Actually the Sacandaga Reservoir was built by the Hudson River Regulating District, a public corporation, and is being paid for by an assessment on all the downstream beneficiaries, public and private, approximately 95 per cent of the cost being paid by the power companies and 5 per cent by the benefitting municipalities.

Finally, it is stated, "Only 3 ft. of storage immediately below the spillway crest is reserved for flood control in the spring", whereas my paper said in this respect, "In the case of the Sacandaga Reservoir the only allocation of storage solely for flood control is that, generally speaking, the 3 ft. of storage immediately below the spillway crest is reserved for flood control in the spring. Only this comparatively small allocation solely to flood control has been made, due to the fact that it was felt that all or nearly all of the control of floods would be obtained if the reservoir were operated for river regulation purposes and it is felt that the 8 years of Sacandaga operation justify this determination".

EDWARD H. SARGENT
Chief Engineer, Hudson River Regulating District
Albany, N. Y., Oct. 28, 1938

Bridge Expansion Bearings

Sir: Referring to the letter of Mr. Schureman (*ENR*, Oct. 13, 1938, p. 453), the writer would submit that Mr. White's challenged statement may or may not be "amazing". The reaction it produces undoubtedly depends upon the individual affected: his views, opinions, experiences, etc.

To the writer Mr. White's statement [that much money is wasted on unnecessary expansion joints—Ed.] appears wholly correct, proper and unamazing. After having examined a very large number of older concrete bridges in the western part of the United States during the past fifteen years it would be the writer's considered judgment that more trouble and more deterioration—to say nothing of more cost—has been accomplished than avoided by the efforts made to provide excessively for expansion.

This statement is not a glib denial of the existence of expansive and contractile temperature stresses. It is to be hoped that no one entertains such ideas. But it is a statement that the extensive jointing of former years has in many cases been far from successful in effecting desired results, that jointing has been and frequently is overdone, that to omit joints completely and to subject considerable lengths of structure to temperature stresses, compressive or tensile, may frequently be wiser and better economy than to employ joints.

Within reasonable limits reinforced concrete can deflect in flexure

(Continued on adv. p. 24)

ENGINEERING NEWS-RECORD

Copyright 1938, by McGraw-Hill Publishing Company, Inc.
Volume 121, Number 19

Editor, F. E. SCHMITT • *Editorial Staff*, V. T. BOUGHTON
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Editorial Offices at 330 West 42nd Street, New York

NOVEMBER 10, 1938

VISITORS may disagree when they look at next year's New York World's Fair buildings, and psychoanalysts may puzzle over the inner meaning of its odd Theme Center. Engineers, however, will know that feats of technical resourcefulness and skill had to be performed before the Needle and Apple became more than a paper conception. The short story in this issue in which Hussey and McKeen effectively report the work of building the Theme structures recounts some of the design and field difficulties; still others had to be worked out, as for instance the general design of the framework, the foundations, and the inner and outer skin construction. Visitors from Finland, Senegal and the Antipodes who come to the Flushing Meadows next spring may miss these fine points while wandering along the Helicline and looking at the Trylon and Perisphere, but they will unquestionably be impressed with the fact that these strange structures required more than routine engineering to bring them into being.

Not a Stunt

ALMOST THE OLDEST pavement type in the world, brick is among the most active in seeking improved ways of design and construction. The steel-reinforced pavement using an 8-in. square brick described on a following page is but one development; de-aired brick, brick laid longitudinally, non-exuding joint fillers, and, latest, a return to monolithic construction with vibrated placement, are under active investigation by field study and laboratory test. Of the recent experiments, the one described in this issue represents the greatest departure from traditional methods. Its service value has still to be tested by time, but it is in no measure an unconsidered construction; many practical road men see a definite place for it in future roadbuilding. The reinforced brick road is not a stunt but is a practical and promising experiment.

Better Cements

FOR TWO DECADES it has been axiomatic that the engineer gets the kind of cement he specifies—a cement of long-time strength gain if this is what he wants; a cement of early strength if that is what he prefers. Modern demand has been strongly in favor of early strength, with the result that most cements have high lime ratios. When Boulder Dam planning led to study of heat generation, however, high lime and hence high tricalcium silicate were found to be detrimental. There followed the elaborate studies and tests on the use of low-heat cement summarized by Meissner and Moran this week. The qualities of this type of cement, though specially advantageous in mass concrete, have some significance also for cement use in general; to say the least the possibilities of fewer cracks and greater durability through the use of low-heat cement raise question whether the demand for early strength at lowest price has not been pushed too far. Gains in other qualities than strength may justify using a cement that costs a few cents more per barrell to produce rather than to try for the highest figure per pound, per square inch, per dollar.

A Good Customer

A SURVEY recently completed by the business department of *Engineering News-Record* shows that 4.5 gallons of diesel oil, 15.1 gal. of gasoline and 1 gal. of lubricating oil are consumed for each $100 worth of new construction. The survey covered 80 engineers and contractors doing $42,000,000 worth of construction work. If these figures can be applied to the total volume of heavy construction, they indicate that last year the construction industry purchased 110,000,000 gal. of diesel oil and 368,000,000 gal. of gasoline. Motor fuel is of course only one of the countless products the construction industry consumes in tremendous quantities. But the survey emphasizes again what a good customer the construction industry is; and, as a corollary, how dependent upon the well-being of construction is general prosperity. Engineers and contractors sometimes forget their own importance in this respect.

Consulting Fees Taxable

REFUSAL of the U. S. Supreme Court to hear an appeal by the estate of the late Joseph B. Strauss from a finding that his income as engineer to the Golden Gate Bridge and Highway District was not exempt from federal income tax makes it obvious that consultants employed by public bodies need waste no further time on attempts to avoid paying income tax on their fees. Though Mr. Strauss was employed by the district as its chief engineer, a position specified in the act creating the district, his pay was a percentage of the cost of the work—quite like a consultant's fee—and the Board of Tax Appeals logically held that he was an independent contractor. This finding was upheld by the Circuit Court of Appeals, which based its findings on a

Supreme Court decision of 1925 relating to fees paid to Metcalf & Eddy while acting as engineers for cities building municipal works. By refusing to hear the Strauss appeal the Supreme Court makes clear that federal income taxes must be included in computing net income from consulting services.

In Others' Footsteps

HOUSING in Great Britain has been so highly praised to this country that it is well to listen to a dissenting voice before we carry our emulation too far. Such a voice is that of O. W. Roskill, an Englishman, who presents in this issue a discussion of the British boom in terms of the design, planning and financing of the houses themselves instead of taking the more usual approach of praising the business that has been generated by the building program. The effect of this business is soon gone; the houses and the debts they represent are long with us.

Briefly, what Mr. Roskill reports for Great Britain is as follows: Of the 1¼ million houses built since 1934, over four-fifths have been the product of private industry. Such quantity production is a result not of planned stimulation but of economic conditions that dropped building material prices and interest rates faster than incomes, leaving the small wage-earner a margin of saving for investment. Much of this speculative building is of poor quality, badly planned individually and badly located and laid out from the community point of view. Very little of it benefits from modernized building codes. Practically all of it is for the lower middle classes, very little for the low-income worker group. Prices range from $2,000 to $4,000. Mortgages cover as much as 90 per cent of the cost and run for as long as 30 years. Hence the building loan societies are beginning to fear that large numbers of poorly built houses will be thrown back on their hands.

Great Britain's private building boom, in short, has been one of quantity but not of too high quality. It would seem, therefore, that there is as much in the British housing program for us to avoid as to embrace. In fact, in our FHA-aided private housing, which constitutes probably half of the current total, we have advanced beyond Great Britain, since structural soundness and good layout and community planning are objectives of the lending agency. As to the other half of the speculative housing total in this country, there is little hope but that much of it is typical "jerrybuilt" construction. It could emulate for its own good the best in Britain as well as in this country.

In one respect Great Britain's experience points a lesson for this country, in that a condition of higher real income, involving lower building costs and lower financing charges, made its boom possible. Perhaps the advent of a similar condition in this country will bring the long awaited increase in housing construction. In the meantime, in our own efforts to modernize building codes, to secure the active support of banks, insurance companies and building and loan societies in promoting sound construction, to assist builders in proper community planning and to simplify and reduce financing methods and charges, we need not look abroad for guidance. In these respects at least we have no reason to follow in others' footsteps.

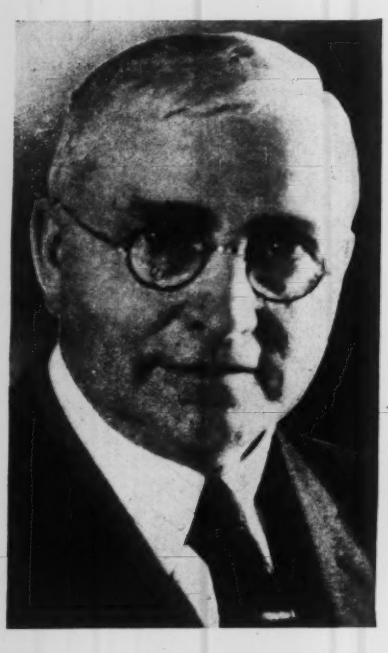
Still a Problem

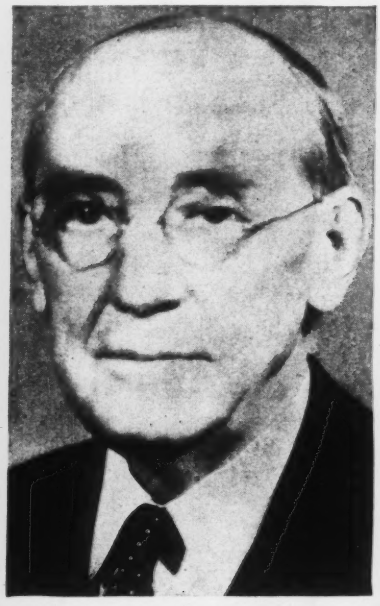
THE RESIGNATION of John A. Lapp as A. F. of L. referee in jurisdictional disputes marks the complete collapse of a promising (on paper) method for eliminating a major problem of building labor. Provision for continuing work by the trade designated by the contractor while negotiations for settlement were under way was the high spot of the plan, originated at the Atlantic City convention in 1935 and made effective by Dr. Lapp's appointment Oct. 1, 1936. Yet, because of lack of sincerity on the part of the building trades and because of the inability of the international unions to make locals abide by agreements, the plan to eliminate a problem that lies wholly in the hands of labor failed, as has every former plan for stopping of jurisdictional disputes.

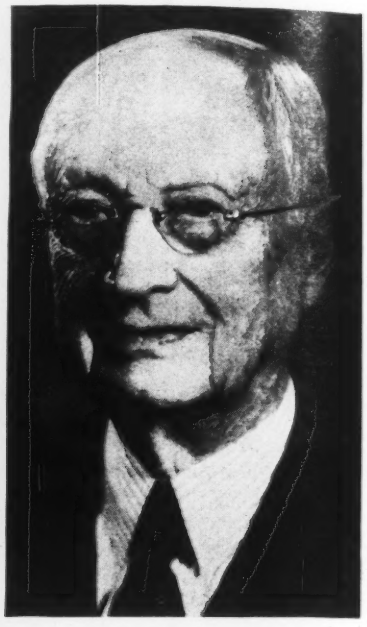
A recent case at Cincinnati illustrates how miserably the procedure failed to work. Carpenters and plasterers both struck, claiming the right to place acoustical material on walls and ceilings; work was tied up, instead of proceeding as had been solemnly promised by high union officials. In due time the referee decided thus: if the material is nailed in place the carpenters get it but if cemented it goes to the plasterers. As this particular material was both nailed and cemented, the decision meant nothing. In disgust the owner finally threw the material off the job and used a substitute. This is typical of scores of cases where jurisdictional disputes have needlessly tied up the job, thrown innocent workmen out of their jobs, hampered adoption of new and improved building materials, raised the cost of work and soured public opinion against construction.

When the building trades come to realize that the jurisdictional dispute is the greatest threat to the craft system in construction and put some real sincerity into their efforts to eliminate it, this major problem will be met. It is labor's own responsibility, though a little intelligent direction from the U. S. Department of Labor might help toward a lasting solution.

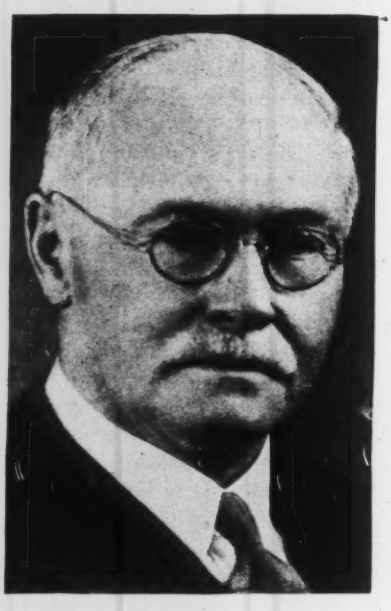
PICTURES IN THE NEWS







AM. SOC. C. E. TO HONOR THESE MEN. At the annual meeting of the Society in January, honorary membership will be bestowed upon five veteran members. They are, left to right: (above) Frank E. Weymouth, chief engineer, Metropolitan Water District of Southern California; Edward E. Wall, director of public utilities, St. Louis; C. Frank Allen, professor emeritus, Massachusetts Institute of Technology; (below) Anson Marston, dean emeritus, school of engineering, Iowa State College; Arthur S. Tuttle, consulting engineer, New York.



A Reinforced Brick Road

Eight-inch square brick, with a steel bar grouted into every joint, are getting an actual road test in Ohio

About 5 mi. north of Delaware, Ohio, on U. S. Route 23, an old (1922) 16-ft. brick road called for revamping. It was decided by the state highway department to repave about 200 ft. of the road with 8-in. square brick and to use a different type of reinforcement in each third of the length. The result is a remarkably interesting bit of road as the accompanying pictures show. Also the experiment has been more studiously undertaken than those made previously; two of the types of reinforcement were fabricated in mats especially for this 8x8-in. brick size and the bricks were cushioned on a stabilized stone base.

The old 16-ft. pavement was laid on a rolled-stone base; this was widened to 21 ft. to carry the new 20⅔-ft. pavement As the new road is designed as half of a future road the inside edge is 3 in. higher than the outside edge. This build-up was made on the rolled-stone base with a feather-edge topping of ½-in. limestone screenings rolled to profile and sprinkled with flake calcium chloride. Side forms of 3x8-in. timber were set for a 20-ft. 8-in. pavement with the form tops at precise pavement surface profile. Between the forms a layer of cushion sand was spread and struck off with a heavy templet riding on the side forms. The finished cushion varied from ½ to 1 in. thick.

The general method of constructing the brick surface is shown by the illustrations. In detail the procedure was a bit different for each type of reinforcement. The types were, in the order of construction, welded bar mats, loose bars and welded wire fabric. Construction started at the south end working north, the start being made from a transverse concrete header. Working north, the west side of the new pavement as it is mentioned hereafter is the curb side and the east side is the future center line when the pavement is ultimately widened.

Welded bar mats

The bar mat portion was first constructed. Each mat consists of 14 longitudinal and 20 transverse ⅜-in. bars spaced and welded at 9-in. intervals in both directions forming mats 13 mesh-openings wide and 19 mesh-openings long. On one side and one end the bar overhang is 1 in. and on the other side and end 4 in.

To start construction, a mat was placed on the sand leveling course with the 1 in. bar overhang end against the concrete header and the 1 in. overhang side along and out 1 in. from the west side form. A half mat was then placed with its 1 in. overhang end against the concrete header and its 1 in. overhang side along the east side curb. In this manner the mats were staggered to make the bar mat 89 brick courses long and 27 brick courses wide. Adjacent mat edges were abutted and spliced at each 9 in. interval by a ⅜ in. round deformed steel rod 30 in. long. An 8x8x3¾ in. paving brick was then dropped in the center of each mesh opening and, as bricklaying progressed, the mats were raised and blocked ¾ in. above the sand leveling course by cement briquet halves. The brick course was rolled with a water-filled hand roller 36 in. wide and weighing 450 lb., the roller being moved at an angle of 45 deg. with the brick joints. After rolling, the surface was straight-edged and corrected in the usual manner.

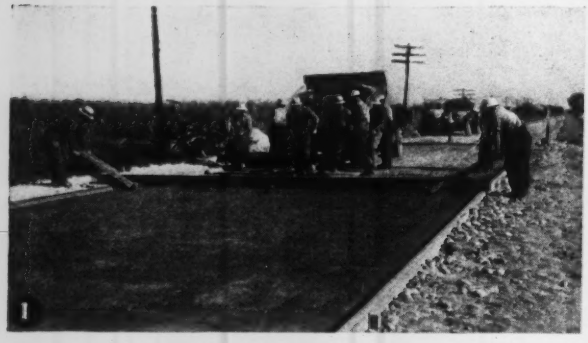
The section was then flushed with a grout of 1 part cement to 3 parts sand by volume and just enough water to insure perfect joint filling and bar coverage; the grout was prepared on the job in a two-sack mixer, conveyed to the pavement in two-wheel buggies and spread by lutes 30 in. wide, edged with ¼ in. rubber belting, which were moved on the pavement at a 45 deg. angle with the joints. As soon as grout setting started, a 24 in. long ⅜ in. round deformed steel bar was placed in the east end of each of the north 40 transverse joints, the rods being sunk ¾ in. below the pavement surface. After the grout setting had caused a depressing of the joints, they were refilled with a somewhat stiffer grout.

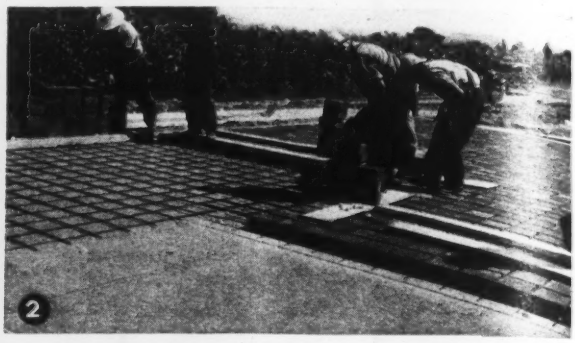
Loose bar reinforcement

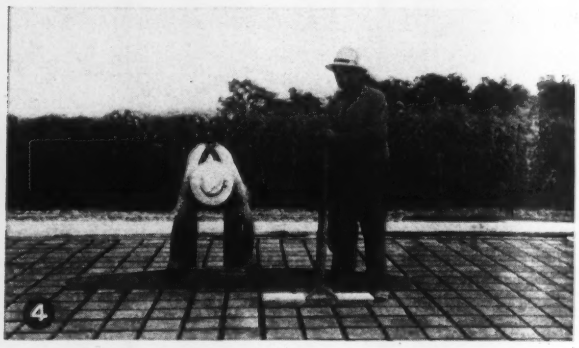
Brick were then laid for the loose bar portion. Sheets of fabric reinforcement were laid on the sand course and bricks dropped in the mesh openings. As laying progressed the fabric sheets were removed. In this manner a section 64 brick courses long and 27 brick courses wide was laid. The 10 ft. 10 in. transverse bars were then placed, being blocked up ¾ in. above the sand course by cement briquet halves and being lapped 15 in. at the pavement center. Two lengths of the 25 ft. 8 in. longitudinal bars were then supported on the transverse bars in each longitudinal joint (and also along the outside edge of the outside brick courses); these 25 ft. 8 in. bars lapped 15 in. back into the bar mat section, lapped 15 in. upon themselves and extended 15 in. past the 64th course.

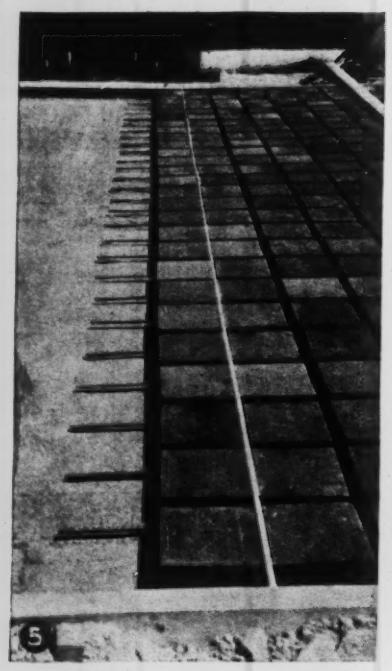
Then, into what would have been the transverse joint between the 64th and 65th brick courses, was placed a wood strip 20 ft. 8 in. long, 3¾ in. deep, ½ in. thick at bottom and ¾ in. thick at top and notched at the bottom to permit passage of the longitudinal bars. The 15 in. projections of longitudinal bars extending past the wood strip were greased and the end capped with ¼ in. length of ½ in. diameter corks. When filled with as-

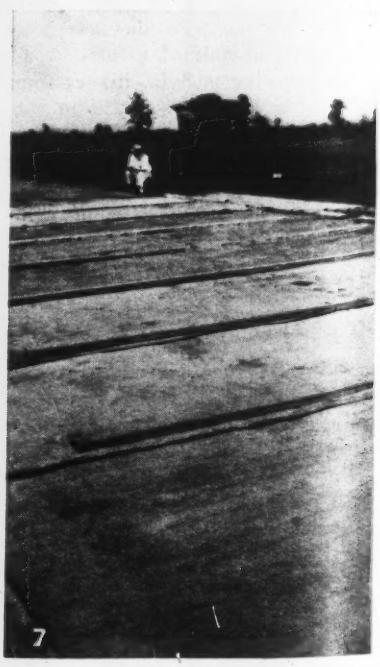
BUILDING A REINFORCED BRICK PAVEMENT











1. A 1-in. sand cushion struck off to exact profile is laid on a stabilized stone base about 9 in. thick. 2. Mats of bars welded into a 9-in. mesh are blocked up on the sand cushion and an 8x8-in. brick is centered in each mesh. 3. When accurately lined up the brick are settled into the cushion by a 36-in. 450 lb. roller. 4. The rolled brick are straight-edged and tamped to true surface. 5. An expansion joint is formed by a wood strip which is pulled after grouting and the space filled with asphalt. 6. Cement grout is poured on the brick and squegeed into the joints. 7. Cotton mats are spread on the pavement and kept wet for five days to cure the cement filler.

phalt this provided the one expansion joint in the middle of the paved section.

Bricklaying then progressed to complete the 89 courses of the loose-bar section. Into this remaining part were then placed the transverse bars as above except that in this case each outside bar end was hooked through a ¾ in. radius and returned above itself for a distance of 13 in. Longitudinal bars were then placed as above, the bars being of sufficient length to extend from the wood strip to a point 15 in. past the 89th brick course. The loose bar portion was then rolled, straight-edged and grouted. As soon as grout setting started, a 24-in. long ⅜-in. round deformed steel bar was placed in the east end of each of the south 40 transverse joints, the rods being sunk ¾ in. below the pavement surface. The finished section was then covered for curing, after regrouting.

Welded wire fabric

The 200-ft. pavement was completed by the addition of a section 88 courses long and 27 courses wide reinforced by welded wire fabric. Each sheet of fabric consisted of 15 longitudinal and 13 transverse wires (¼ in. round cold-rolled steel) spaced and welded at 9-in. intervals in both directions thus forming sheets 14 mesh openings wide and 12 mesh openings long. To start this portion a full sheet was placed against the end of the loose-bar section, along the west side form. A three-fourths length sheet was then placed against the end of the loose-bar section along the east side form. In this manner the sheets were staggered to make the fabric section eight sheets long and two sheets wide. Adjacent sheets were lapped one mesh. As bricklaying progressed by dropping bricks in the mesh openings, the fabric sheets were blocked up to the center of the brick depth. The finished section was then rolled, straight-edged, grouted and covered for curing as described above.

Direction

The test road was constructed by the Ohio State Highway Department in cooperation with the National Paving Brick Association, the Concrete Reinforcing Steel Institute and the Wire Reinforcement Institute.

Simple Soil-Test Machine

GREGORY P. TSCHEBOTAREFF
Assistant Professor of Civil Engineering, Princeton University, Princeton, N. J.

Shear test machine convertible for compression tests developed at Princeton University soils laboratory

A SOIL SHEAR-TEST machine for samples not exceeding 3x3 in. has been developed at the new soils laboratory at Princeton University. It is compact and inexpensive and has given good results in routine tests and in research work. A simple change permits compression tests to be made. Fig. 1 shows the general appearance and Figs. 2 and 3 explain the operation of the machine.

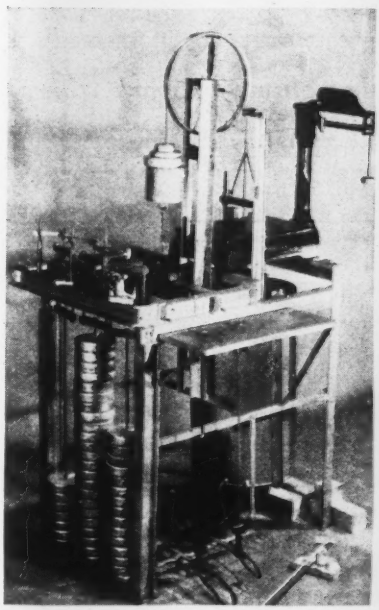


Fig. 1. Soils shear-test machine convertible for testing compressive strength.

Referring to Fig. 2, the shearing force is applied by filling at any desired rate the counterweighted water tank *A*. A float *B* in the tank is connected to an indicator *C* which shows the actual weight of excess water in the tank, that is the shearing force applied to the soil sample. The scale *D*, which is used to calibrate the indicator scale, also serves to make control weighings of the water in the tank after each test. A swivel pulley *E* and detachable yoke permit the shearing force to be applied to the lugs of the shear box. Normal load is applied to the shear box by weights *F*.

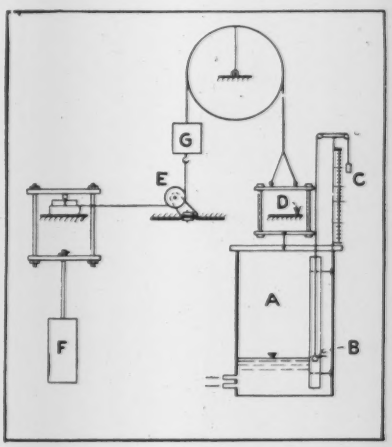


Fig. 2. Schematic diagram of the operation of the soils-shear test machine shown by Fig. 1.

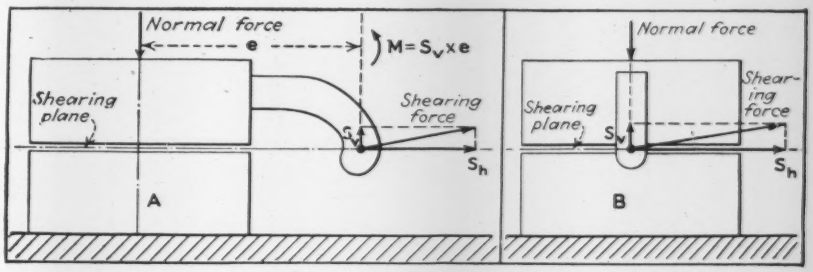


Fig. 3. New method of applying shearing force so as to keep it in line with the shearing plane.

The soil sample can be completely submerged during the test. This feature has been taken over from a machine recently designed at the M.I.T. laboratory but other features are believed to be novel. In most shear boxes, with the shearing force applied as shown by Fig. 3A, the upper movable part of the box can tilt when the shearing force does not coincide exactly with the shearing plane; even with very careful adjustment it is difficult to avoid a slight inclination of the shearing force. By the new arrangement (Fig. 3B) the shearing force is applied at the intersection of the shearing plane with a plane through the normal force. Any vertical component of an inclined shearing force will then only slightly alter the value of the normal pressure. Both porous stones and metal plates with ribs may be used in studying the effect of consolidation on shearing resistance.

When compressive-strength tests on laterally unconfined soil samples are required, the counterweight *G*, Fig. 2, is disconnected from the shear boxes and the soil sample is placed on the platform of the scale *D* beneath the yoke from which the loading tank *A* is suspended and which transmits to it the normal compressive force by a reduction lever.

The whole machine requires only 30 sq. ft. of floor space and costs, complete with all dials, weights and fittings, only about $450. One man can handle it and take the required readings.

I express my acknowledgments to professors George E. Beggs and Elmer K. Timby for valuable suggestions concerning the design of some of the improvements made on the machine.

Housing in Great Britain

O. W. Roskill

London, England

Despite the notable volume of work, there are difficulties with jerrybuilding, high costs, poor planning, and a lack of accommodations for the low-income group

Since the World War, 3,300,000 new houses have been built in Britain, and one-third of the population has been rehoused. A high proportion of the total has been crammed into the last few years, over 1¼ million houses having been built since March, 1933. Whereas in the earlier post war-years the building of small houses was possible for the most part only with the assistance of a government subsidy, more than a million of the houses built in the last four years have been erected by private enterprise.

What have been the reasons for this colossal expansion in private enterprise building and what are the effects on the housing conditions of the people?

Prior to the slump even state-assisted building was largely incapable of providing housing to suit the pockets of the lowest-income classes. With the slump years came a great fall in the cost of living, which far exceeded the fall in money incomes. Hence real incomes rose, and the skilled worker, the clerk and the small shopkeeper found himself with a substantial surplus of income after paying for bare necessities. This surplus in part, was invested, and when the average middle-class or working-class Englishman thinks of saving he thinks first of buying a house in which he himself can live. At the same time the fall in the price of building materials and in the rate of interest greatly facilitated the production of suitable houses at the right price. In short, a sudden change in the basic economic factors made possible the satisfaction of an accumulated social demand for new housing, which had remained unsatisfied for many years.

Building for the middle classes

The changed economic situation presented a golden opportunity to the speculative builder and the building society. The former started to buy large tracts of land in suburban areas, subdivided them into plots and built on each plot small houses at the rate of 8, 10 or even 12 to the acre. The building societies assisted the would-be purchaser to buy these houses by deferred payments, and by the end of 1936 the total balance due on building society mortgages stood at £586 millions.

Since 1933 these building societies have been prepared to advance 90 per cent of the building price of working-class houses (the purchaser putting up the remaining 10 per cent and the whole price of the land) on mortgages running up to 30 years and bearing a rate of interest varying from 4 to 4½ per cent. But in practice hardly any working-class houses have been built by private enterprise, and on building society business as a whole the rate of interest charged has probably been rather higher and the proportion advanced more in the neighborhood of 75 per cent. The average amount advanced has been about £500.

These are the bare facts of the financing of a major part of the boom in private housebuilding, which is now showing definite signs of drawing to a close as economic conditions become less favorable.

Speculative building activity was concentrated on providing the type of house required not by the unskilled wage-earner but by lower middle class and skilled wage earners, with family incomes of £3 10s. or £4 per week and upwards. The unskilled man is seldom of sufficient

substance or security to buy a house even on the deferred system and cannot really afford a rent of more than 10s. per week, though he is often compelled to pay 12s. to 15s. per week, including services.

Speculative estate houses are nearly all for sale, and the weekly payment works out in most cases at anything between 15s. and 25s. per week spread over 20 or 25 years, according to situation and size, plus service rates (normally not less than 3s.) The lower-middle-class market for this type of house has gradually been approaching saturation, and in consequence speculative builders have been directing their attention toward building a type of house which sells for as little as 10s. per week, and even building a few houses for letting. But the proportion of houses of this type has been small. Speculative enterprise as a whole has received a decisive check from the adverse trend in building costs and in interest rates.

Such ribbon developments as this one at Sanderstead, Surrey, swell the building volume figures but represent bad planning and inefficient use of ground and add to transportation difficulties.

Subsidies for working classes

Under the 1933 Housing Act, which was essentially a financial measure, the *general* subsidy for working-class housing, which had been available previously, was withdrawn and replaced by two *special* subsidies designed to encourage the building of new working-class dwellings by local authorities for the specific purposes of slum clearance and the elimination of overcrowding. These subsidies have not led to much increase in the *total* amount of working-class accommodation. That was left, somewhat vaguely, to the not very satisfactory process of "filtering up." In practice not much benefit has accrued from this process, partly because the growth in the number of separate families, which had been retarded hitherto by the impossibility of obtaining suitable separate accommodation, has prevented much old property from becoming vacant, and partly because landlords are sometimes reluctant to allow the class of their property to "deteriorate" by admitting working-class families.

Municipal building with the aid of new subsidies is directed toward the replacement of working-class dwellings demolished under slum-clearance schemes and toward providing additional accomodation in order to eliminate overcrowding. About half the original slum clearance program has been completed, but the original plans have twice been stepped up. Building for the elimination of overcrowding has hardly begun. In all, about 600,000 houses in England and Wales alone are required to complete these programs, and of these upward of 400,000 remain to be built. Work on these contracts will, consequently, do something over the next five years to counteract the decline in speculative building, though it will undoubtedly also result in a geographical shift of housebuilding activity from the South to the big industrial towns of the North and to some extent from suburban estates to central cities.

To sum up, speculative building has done much over the past five years to meet *in quantity* the expansion demand of a section of the population above the lowest income levels. As for the needs of the working classes, state-assisted building has made some progress in respect to amount of housing available.

Quality is questionable

It is the quality, rather, of some of the new building which gives rise to misgiving, both on account of faulty construction and, in the wider social aspect, because of bad planning. It is impossible to measure statistically the exact significance of bad building in the total, but most of it occurs on the speculative estates and very little on the municipal housing projects.

The average lower-middle-class house in a speculative estate is a detached or semi-detached building on two floors. It is built almost invariably of brick (which may be partly or wholly covered with roughcast or imitation timbering) and roofed with cheap clay tiles, or increasingly, with concrete or asbestos-cement tiles. It contains two small living rooms (rarely, one large one) and a small kitchen on the ground floor, and two or three bedrooms (one probably very small) above, with a bathroom. It is wired for electric lights and usually has little provision for heating other than an open fire in the living room. Occasionally there is a very small refrigerator, sometimes a telephone. Many of these houses are practically devoid of closet space.

The average house stands on a plot varying in size from one-tenth to one-sixth of an acre, and in some cases containing a garage or more usually "space for garage." The price would vary from about £350 for a maisonette with one living room and two bedrooms to as much as £1,000 for two living rooms, four bedrooms and garage in a fairly large plot. The usual price range is from £450 to £750. Weekly payments may vary from 10s. to more than 25s.

For working-class houses the most commonly accepted standard is a non-parlor house with three bedrooms, a total floor space of 760 sq. ft. and built at a density of not more than 12 to the acre. This, or the equivalent dwelling in a flat block, is meant to accommodate a family of five, but does not become overcrowded in the legal sense until occupied by more than 7½ persons, counting a child under 10 as half a person and disregarding infants. Many smaller houses are, of course, built for smaller families, and it has been shown that a very satisfactory 3 bedroom non-parlor house can be built with floor space of only 600 sq. ft. by careful attention to details of design. The average price of the house first mentioned during the period 1932-35 was from £285 to £300 but the cost has been rising steadily since, and in the first quarter of 1937 had reached about £340. Land and development costs vary according to situation, frontage and density of development; in some cases figures figures as low as £15 per house are known, but £30 to £75 is the usual range, the higher figure being nearer the mark for suburban areas around London.

Some condemnation

The faults in the construction of such of the houses on speculative estates as are generally characterised as "jerry built" are seldom sufficiently serious to render them legally unfit for human habitation, though a case is known where a substantial portion of an estate commenced in 1934 has already had to be condemned under the local slum clearance program. The commonest structural faults are as follows: foundations of insufficient depth, and surface concrete of insufficient thickness to provide an efficient dry air space beneath the building; inadequate damp-courses for the prevention of internal moisture in the walls; porous walls due to the use of the very cheapest bricks (usually hidden behind roughcast) and bad bedding; use of timber of inadequate dimensions for rafters and joists (the timber is sometimes insufficiently seasoned and of bad quality as well); use of poor clay tiles, leading to flaking and subsequent leakage; bad plumbing, including the encasement of lead pipes in cement rendering, leaving inadequate allowance for expansion and contraction; deficient electric wiring (slip-joint conduits are often used and conduit tubes are often not run right down to the switch so that rewiring is practically impossible); insufficient "curing" of the structure before decorating, and the use of inferior paint; use of unseasoned timber in windows and doors, resulting in warping and the development of leaks.

These defects do not necessarily occur simultaneously but all of them are fairly common. In other cases the materials used may be satisfactory but undue haste in construction, the employment of semi-skilled labor on skilled work at less than skilled wages, and lack of adequate supervision (many speculative builders do not employ an architect) result in faults due to slipshod workmanship. On many speculative jobs, nearly all the craft work is let out to subcontractors on a piecework basis, which greatly increases the difficulties of supervision and encourages scamped work.

The average citizen is, of course, not equipped to distinguish the sound from the unsound, and even the expert may not be able to detect faults until the trouble actually begins. And as against the possible presence of structural defects, internal fittings, such as tiled kitchens and bathrooms, refrigerators and automatic water heaters, which the American housewife might well accept as a matter of course, "artistic" fireplaces and mock "old-world" effects, though often extremely shoddy and badly planned, prove strong selling points with the average English housewife, to whom such features have hitherto been luxuries.

Must pass surveyor

According to the law, the plans of every house built in this country must first be passed by the local surveyor as conforming to the local by-laws affecting building, and the house itself must be passed on completion. But this in practice has been no guarantee of sound construction. In the first place, by-laws have been built up by rule-of-thumb, and conformity need not necessarily, in the light of modern scientific knowledge, result in sound construction. Fortunately, the building by-laws are now in process of revision. In the second place, nothing less than frequent and rigorous inspections of the house during erection by a local authority surveyor would suffice to enforce conformity.

Accordingly, a number of cases could be cited where purchasers of houses have, within a year or two of moving in, become profoundly dissatisfied with their purchases and have even taken successful action against the builders for failure to fulfil their specifications or clear violations of by-laws. Instances are known where the purchasers of houses on speculation estates have set up protection associations to fight for their interests against the builders, and have taken active measures, which the builders have been powerless to prevent, to warn off other purchasers. But whereas really serious structural deterioration in the first few years appears to have occurred in rare instances, the standard of construction of a very substantial proportion of speculative houses has been so cut to the bone that heavy repairs will be required even before the mortgages have expired.

The situation is causing some concern to the building societies who are faced with the possibility of having numbers of new houses of which they are still, and will long remain, the legal owners, thrown back on their hands by bankrupt householders. The social implications also are somewhat disquieting.

In the past, middle-class housing property has mostly been held in large blocks by landlords of some financial substance who have had an obvious financial interest in maintaining it in a condition which was at least more or less habitable, even if the standard was low. And the property which they held, although it may have been anything up to a hundred years old, was undoubtedly more enduring structurally than most of the building estate houses erected in the last few years. The speculative building boom has involved a great multiplication of minute freeholds of which the present occupiers, or their successors, will in course of time become the unrestricted owners. Although the existing occupiers will obviously be even more interested than the older landlord class in maintaining their houses in good

habitable condition, their financial standing is in many cases weak, while the cost of upkeep will necessarily be heavy. Moreover, there is no reason to suppose that their successors, in, say, 20 years time, will be equally interested in keeping the new property in repair.

The fears that have been expressed, therefore, that the new building estates of the past few years may deteriorate into the slums of the future are by no means unfounded. It must, however, be remember that one of the principal features leading to the creation of slum—the pressure of increasing population—is not likely to be present. So that the threat is one of areas of derelict and decaying property rather than of the reproduction of the overcrowded urban slums of the nineteenth and early twentieth centuries.

The building societies have been clearly alarmed by this jerry building menace and have co-operated with some of the more far-sighted members of the building industry in setting up a National Housebuilders Registration Council to enlist the support of builders and to bind them to observe standard building practices set up by the council. Houses which conform to the council's specifications, as checked by a series of thorough inspections during erection, will receive a special certificate which will, no doubt, add to their market value. It remains to be seen how much support the council will receive from the industry; unfortunately its efforts would appear to have been made too late to affect materially the quality of building during the present boom.

Bad planning

Bad planning has probably been much more widespread than substandard construction. It has been of two kinds—bad planning of the houses themselves in relation to the requirements of the families who are to occupy them, and bad planning of housing development as a whole in relation to industrial development, transport, amentities and social requirements in general. Bad internal planning is partly due to lack of education in this matter of the occupier himself, who is apt to be dazzled by the more superficial attractions dangled before his eyes by the speculative builder. But it is due also to ignorance on the part of the builders, combined with their almost complete failure to employ competent technical consultants; and to the deliberate cutting of costs. The result has been the erection of houses which, by reason of insufficient attention to details of design, will cost the housewife more to run.

The cost of bad planning of housing development in general unfortunately falls not so much upon the individual builder or occupier as upon the community as a whole. Consequently, bad planning has been very difficult to stop, since it has not generally had any adverse effect on individual profits. The garden cities of Welwyn and Letchworth are known the world over, but they are in fact some twenty-five years old and originated as essentially residential schemes, having only lately been developed on their working class and industrial side. Better modern examples are the great Wythenshawe estate of the Manchester municipality and the housing estate of the city of Leeds. On the other hand, some of the efforts of other municipalities—notably some of the large suburban estates of the London County Council—have been less happily conceived in the community aspect. One of the largest L.C.C. estates, at Dagenham, is frequently criticised on the grounds of distance which the occupants, many of whom were moved from the middle of London, have to travel to work and to shop, and consequently suffers from a high percentage of vacancies.

The principal evil has been ribbon development, by which our large towns have grown amorphously outward along their arterial road communications, with little coordination between industrial, commercial and residential development. The results have been a steady encroachment upon suburban open spaces and the moreesthetic amenities necessary to ensure a healthy and balanced life in the cities, and a costly and vexatious congestion of the transport system. Suburban transport round London, for instance, has to cope every morning with two opposing streams of passenger traffic, one moving to work in the factories outside, the other coming in to work in the metropolis. Moreover residential development in attentuated ribbons along the traffic arteries instead of in compact extra-suburban units has virtually inhibited the possbility of fast non-stop transport services from residential to commercial and industrial areas. Failure to coordinate industrial and residential development has of course both complicated the labor problem of industry and greatly increased the cost to the wage earner of traveling to and from his job.

Legislation has been improvised to deal with the problems of town planning and ribbon development, but it faces the costly and almost insuperable problem of compensation of landowners for loss of land values if, in accordance with the best requirements of community planning, the user of land outside cities for different purposes is to be arbitrarily controlled. Further, the town plans which exist on paper and, indeed, carry statutory force, do not in practice exercise much control over anti-social development.

The cost of all of this bad planning will have to be borne, perhaps for the most part unwittingly, by the community in the widest sense. The price paid already by the unnecessary overloading of existing arterial roads has been considerable. The cost of redevelopment would be prohibitive. For the next thirty or forty years the cost of bad planning and the debasement of esthetic values can only be borne with such equanimity as is possible, and the best efforts exerted to prevent recurrence.

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Slow-Motion Driving Unlawful in 22 States

THE FORTY-EIGHT STATES are almost evenly divided on the question of giving legislative recognition to the idea that ultra-slow drivers, like ultra-fast drivers, are highway menaces.

A total of twenty-two states now have minimum-speed laws in effect, the measures following three general patterns. Twelve states provide that no person shall drive a vehicle so slowly as to impede traffic, with penalties being generally the same as for speeding. Six states stipulate that driving speed shall be neither greater nor less than is reasonable and prudent. Four others merely require that slow-moving traffic shall "keep to the right" and not impede traffic approaching from the rear.

Building the "Needle" and the "Apple"

H. D. Hussey and E. E. McKeen

Designing Engineer and Assistant Engineer respectively, American Bridge Co., New York, N. Y.

Theme structures at New York World's Fair consisting of a 180-ft. diameter sphere and a 610-ft. sharp-pointed tower provide new fabrication and erection problems

A STEEL DESIGN and erection problem of uncommon kind was presented by the group of uncommon structures chosen to symbolize the theme of the New York World's Fair. Given the imposing names of Perisphere and Trylon, which the steel workers promptly shortened to "Apple" and "Needle", the structures, which are adjacent to one another, consist of a 180-ft. diameter sphere and a 610-ft. triangular tower. Inside the sphere will be installed the theme exhibit of the fair which will be viewed by visitors from two revolving platforms reached by escalators connecting the base of the tower with entrances to the sphere, 52 and 64 ft. above the ground. Exit from the sphere will be over a bridge to the tower and then down a long winding ramp, named the Helicline, to the ground. Because of the extremely complicated nature of the steelwork, requiring careful study of detail as well as design, and because insufficient time was available to develop complete architectural and structural designs before the contract was awarded, the development of details, design and architectural features proceeded simultaneously. This type of cooperation proved of distinct benefit to owner, architect, designer and builder.

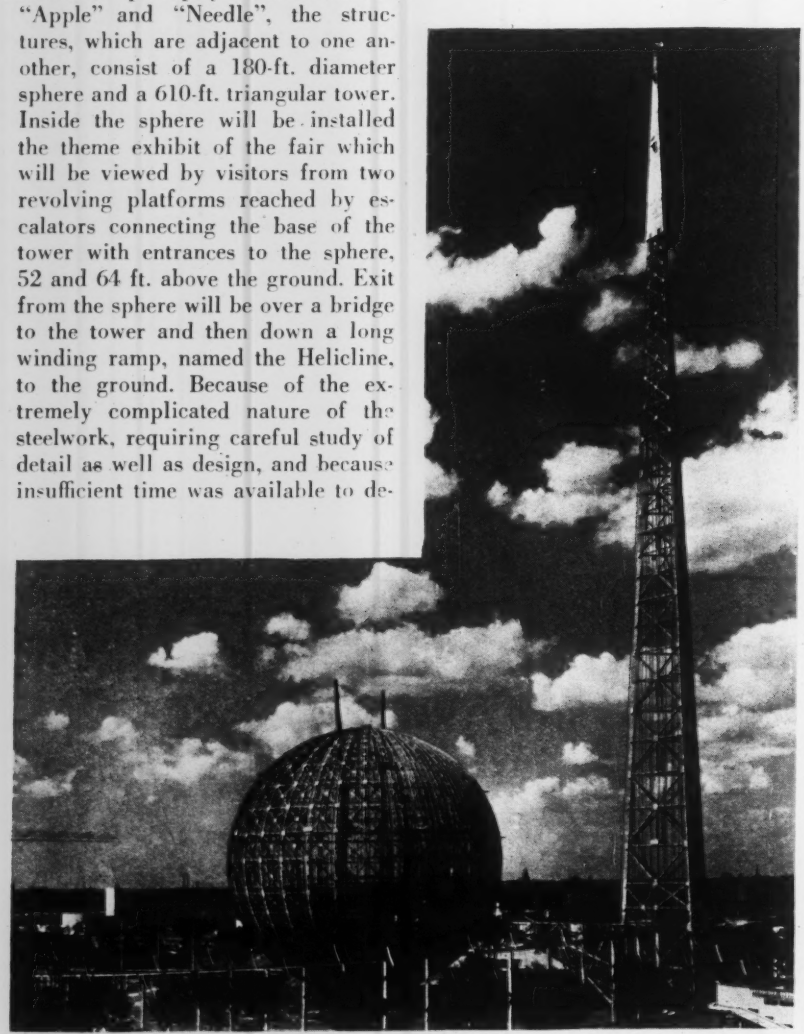

Fig. 1. Imposing names of Perisphere, Trylon and Helicline are given this sphere, tower and ramp, forming the Theme Center of the New York World's Fair.

The structural steel frame of the Perisphere, weighing 2060 tons, consists of 32 meridian trusses, connected top and bottom by circular drums and braced apart by 15 girt trusses, which extend around the structure, and by a complete system of diagonals. Near the bottom, the trusses frame into a ring girder of box section, 7½ feet deep and 72 ft. in diameter, supported on eight steel columns. The inside chords of the trusses, 162 ft. 7 in. in diameter, form a complete circle, while the outside chords, 178 ft. 7 in. in diameter, are circular down to the intersection of the bottom of the ring girder where they become horizontal. The trusses are 5 ft. deep at the top and, if continued in circular form, would be 11 ft. deep at the bottom. This places the center of curvature of the inside 3 ft. above the center of curvature of the outside, a condition which added to the difficulties of design and construction. Purlins cover the entire outside, to support the sheathing, and are used as well on the inside surface; to support them both chords of the grit trusses are curved. The bracing on the outside surface is composed of straight members with bent-plate connections.

The Trylon, 63 ft. wide on each side at the base and 2 ft. 7 in. on each side at the top, is a braced tower for the lower 500 ft., above which it is composed entirely of ¾-in. steel plate. Vertical purlins, spaced about 4 ft. 10 in. cover the lower portion to provide support for the outside covering. The tower steel, of which there is 860 tons, contains some large members, each of the three columns having sectional areas of 250 sq.in. at the base. Floors are installed at El. 25, 50 and 300 ft. above the ground, with stairs and

an elevator extending to the 50-ft. level, the elevation of the bridge and Helicline. The upper part of the Trylon will not be used and is therefore equipped only with ladders.

The bridge connecting the Trylon and Perisphere is a complicated structure which supports the two escalators and affords means of exit from the Perisphere to the Helicline. The steelwork in the Helicline consists of 44 bents, each with a single tubular column (16 to 30 in. in diameter and from 10 to 50 ft. high) and a rigidly-connected floorbeam across the top. Transverse rigidity is supplied at the base by a built-up spread footing riveted and welded to the column shaft, while longitudinal rigidity is supplied by the three lines of floor stringers.

Development of the steelwork

As stated, at the time of award of the contract for the fabrication and erection, in July, 1937, it was realized that close cooperation on the part of the contractor, the designer and the owner was necessary. Accordingly, a group of engineers and draftsmen was organized in the New York office of the American Bridge Co. Two of these men were from the office of Waddell & Hardesty, consulting engineers, and designers of the Trylon, Perisphere and bridge; five were from the construction department of the World's Fair; and two were from the drawing rooms of the fabricator.

The principal task assigned to this group was to develop the general details of the steelwork, which was done by the fabricator's draftsmen, and to develop the complicated steelwork at the entrance to the Perisphere and in connection with the revolving platforms, which was done by the World's Fair engineers. The general design was being completed at the same time by the consulting engineers. All of this work called for much collaboration with other groups working in the offices of the owner and designer, but the result proved that the procedure was of distinct benefit in expediting the work.

Inasmuch as the steel work in the Perisphere was the most complicated that has ever come within the experience of the engineers connected with the work, a small wooden model of the sphere was constructed by the fabricator as an aid in visualizing the more difficult parts of the structure. This model, 2 ft. in diameter, was used to good advantage in the designing office, the drawing room and the template shop.

The members which gave the most difficulty were the girt trusses, the chords of which are arcs of great circles, between corresponding points on adjacent meridian trusses. The fact that the center of curvature of the outside and inside of the steelwork does not coincide added to the difficulty in detailing these girts, as well as in fabricating them.

Fabrication

Fabrication of the Perisphere presented special problems to a shop where curved work is the exception rather than the rule. To make 32 curved trusses of exactly the same length, a jig was devised large enough to accommodate an entire truss from the ring girder to the top. The outside and inside arcs of the trusses were laid out very carefully, and the chord angles, which previously had been curved, were made to match these arcs, where necessary by shimming against angles welded to the tops of the jig beams. The remaining pieces of the truss sections (each truss being in nine sections), were then assembled and riveted. The positions of the field splices were accurately located on the jig, and the splice connections reamed with adjacent sections assembled. The girts, of which there were more than 400, were also assembled in jigs.

Fabrication sequence was governed by erection requirements which divided the structure into horizontal divisions. Thus, work began with the lower sections of the meridian trusses. Then, before a truss section was removed from the jig, the next section above it was assembled so that the field connections could be reamed. With this reaming complete, the steelwork of the lower division was shipped from the plant, and fabrication on the next division followed the same sequence of operations.

The bottom sections of the trusses were completely assembled with the ring girder and the drum to which all trusses connect at the center. The value of this assembly was later proved by the ease of erection.

Erection of the Perisphere offered a difficult problem because of its bulkiness and unusual shape and

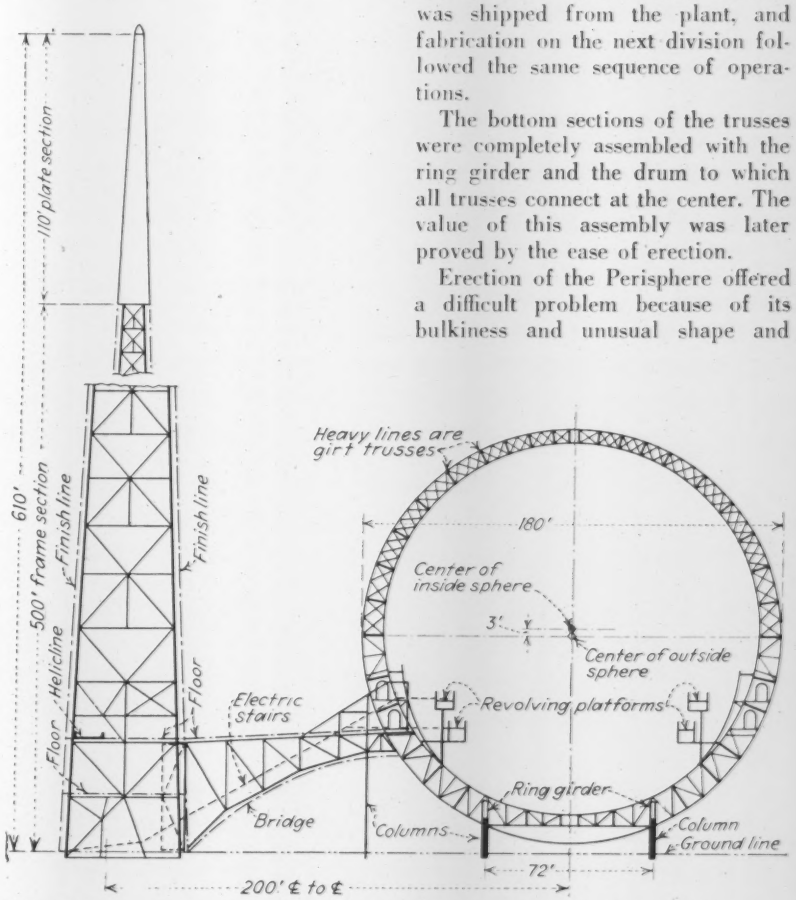

Fig. 2. Steel framework of the Fair's theme structures. Visitors riding the revolving platforms in the sphere will view the "world of tomorrow" laid out below them.

because it required handling 6,000 separate pieces and the driving of 100,000 field rivets. In addition, it was required to erect a complete tier of meridian trusses, together with the girt trusses, before the next tier was begun. Two types of equipment were used. A 20-ton crawler crane operating on the ground erected the base columns, the eight segments of the ring girder and all of the truss work to the equator; the only falsework necessary was to support the 8-ton center drum in the base while the lower truss sections were being erected between the drum and the ring girder. Erection of the steelwork above the equator of the sphere was accomplished with a 30 ft. square erection tower 90 ft. high equipped with two 12-ton 97-ft. boom stiffleg derricks. This tower was supported on the meridian trusses inside of the ring girder, each corner of the tower being carried by three trusses.

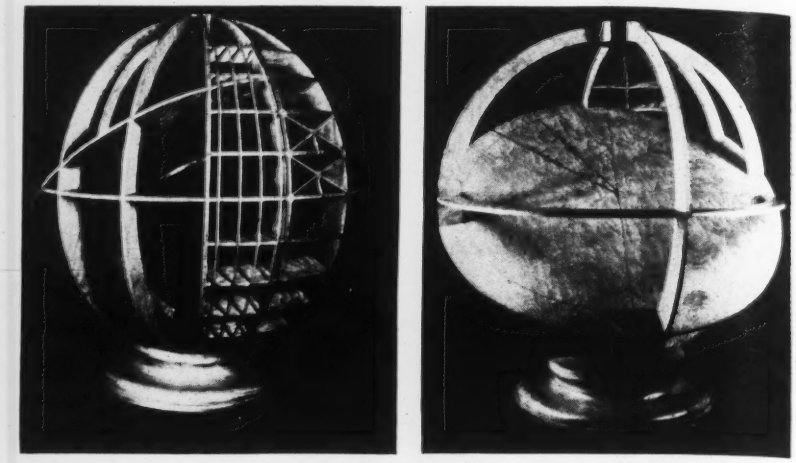

Fig. 3. Two views of the wood model of the sphere that found effective use in both design rooms and shop.

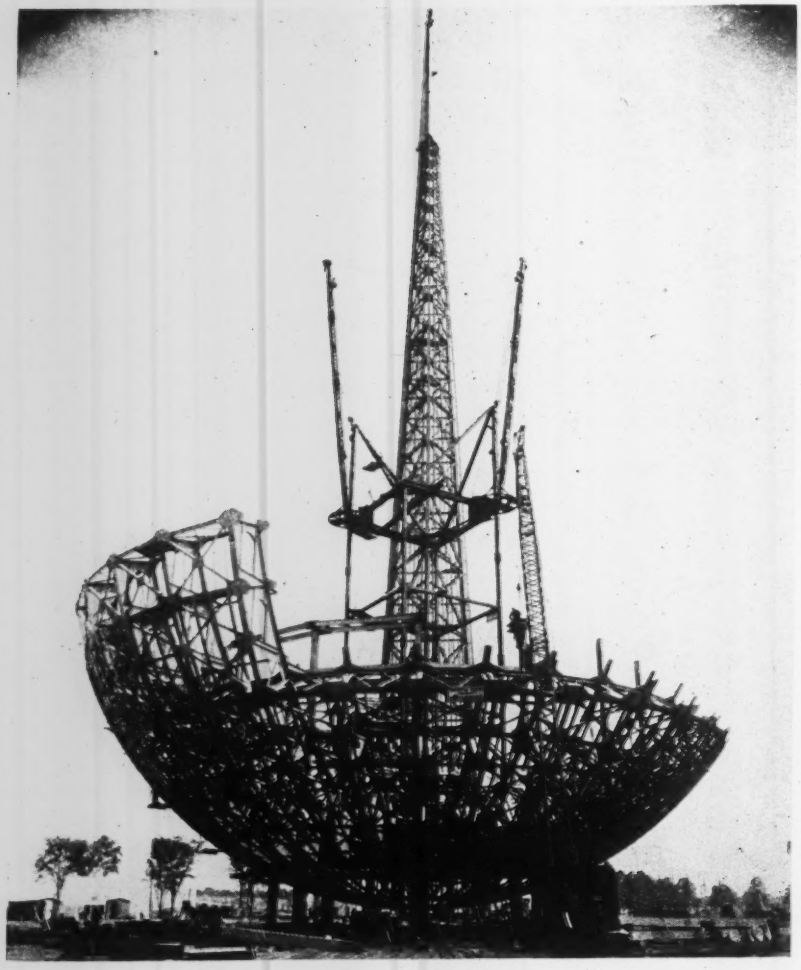

Fig. 4. Sphere erection was carried out by two types of equipment: a crawler crane placed steel up to the equator while the top structure was erected by stiffleg derricks on a tower inside the sphere.

A meridian truss section was from 5 to 10 ft. deep, 30 to 40 ft. long, and weighed from 2 to 5 tons. As each section of a truss was erected, it was attached with drift pins and bolts so that it cantilevered from the next lower section. Then an adjacent truss section of the same tier was erected in the same manner, and the horizontal girt trusses and diagonals placed between. This procedure was continued around the sphere for each tier of steelwork.

Accurate shopwork eliminated any difficulty in connecting the horizontal trusses and diagonals. Riveting followed erection and fitting up very closely. After two meridian trusses were complete, the top center drum was erected with both tower derricks and attached to the trusses with temporary connections, after which the steel erection was brought to completion. To allow for fabricating variations, the permanent connections of the meridian trusses to the drum were left blank to be drilled after all the steel was erected.

Trylon erection

The principal erection problem on the Trylon resulted from the fact that the structure tapers to a very small dimension at the top, which required heavy lifts to be handled by a basket ginpole. Three different pieces of erection equipment were successively used on this tower. The first, a 30-ton crawler crane with a 100-ft. boom, was used to erect the lower 90 ft. Next, a 77-ft. basket ginpole, composed of four angles laced together, was used to erect to

the 425-ft. level. Above this point a 10-in. diameter gas pipe ginpole, 70 ft. long, was used to complete the structure.

The basket ginpole was supported by three fixed guys of 1½-in. wire ropes about 35 ft. long, running from hitches on the column sections to a spider at the bottom of the pole. Three topping lift falls, operated by separate drums on a hoisting engine, controlled the top of the pole. The lead line for the load falls ran up through the center of the pole and over a sheave at its top. The heaviest lift was 14 tons at a 40-ft. reach.

The pole was jumped by three jumping falls, the lead lines of which were fastened together at the bottom of the tower and attached to a set of 1½-in. manila rope falls which led to a niggerhead on an engine. The attachment of these various wire ropes to the tower was supplied, at each position of the pole, by hitches riveted to the inside face of the columns and equipped with three 2½-in. diameter holes. The upper hole accommodated the topping lift falls, the middle hole the fixed bottom guys and the lower hole the jumping falls.

To erect the upper frame portion of the Trylon and all of the plate sections at the top, where inside clearances were small, a gas pipe ginpole was used. This pole was operated similarly to the basket ginpole but the maximum lift was 5 tons. For the last 60 ft. this pole was held in position by five ¾ in. wire rope guys running from a spider at the top of the pole to deadmen on the ground and then to drums on a hoisting engine.

Construction at the World's Fair is under the direction of the construction department of the New York World's Fair, 1939, Inc. The architects for the Theme Center were Harrison & Fouilhoux, and the foundations were designed by Moran, Proctor & Freeman, consulting engineers. The Trylon, Perisphere and bridge were designed by Waddell & Hardesty, consulting engineers, and the Helicline by the construction department of the World's Fair. American Bridge Co. was the contractor for fabrication and erection.

The Field for Low-Heat Cement

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What has been learned of the advantages and limitations of this new product after extensive research and the use of 5,000,000 barrels of it in the field

LOW-HEAT PORTLAND CEMENT is a special product developed from Boulder Dam research for use in massive concrete work. In chemical composition, it is a cement of lower lime and higher silica and iron content than the ordinary standard Portland cement and, in addition, it is ground slightly finer. Up to the present time, the Bureau of Reclamation has used 4,860,000 barrels of low-heat cement in four dams. At Boulder Dam the average mill price was $1.46 per barrel as compared to $1.40 per barrel for standard cement. Eight large cement plants in this country have participated in the production of this cement without material changes in their equipment or accustomed methods of operation. It is the purpose of this article to present a brief review of the factors leading up to the introduction of this cement, the researches on which it is based, and, primarily, the experiences gained in its employment and production.

Prior to the time plans were being formulated for Boulder Dam, it had been noted that the combination of construction speed, increasing size of structure, and rapid hardening cement, with attendant greater evolution of heat, had resulted in increasing the volume change in mass concrete and consequently had accentuated the number and width of contraction cracks. Cracking is objectionable in any structure, but in dams especially it should be avoided since cracks, directly or indirectly, affect stability, permeability, appearance and durability. Heat generated by hydrating cement raises the temperature in large concrete masses considerably above that at which the concrete is placed, and shrinkage then accompanies subsequent cooling to ultimate stable thermal conditions. This shrinkage, and the inability of concrete to adjust itself to such volume reduction without tensile failure, are the primary causes of cracking in mass concrete.

The term mass concrete has come to be applied to concrete of such proportions and nature that these temperature effects become consequential. No distinct line of demarcation can be drawn between mass and other concrete, although massive dam sections and thick walls are conceded as belonging in the former category. Variations in the moisture content of such concrete, through drying, has been demonstrated by test and calculation to be confined to a relatively slight depth at the surface, and therefore, responsible only for superficial shrinkage cracks which may be afterward enlarged by other forces. This latter type of volume change, on the other hand, does become serious in structures not classed as mass concrete.

In order to ascertain the various factors which influence volume change and to devise means for reducing high internal concrete temperatures, the Bureau of Reclamation initiated an extensive program of research in mass concrete in the early part of 1931. The cement investigations included in this program had as their basis the previously published work on portland cement constitution by Bogue and his associates of the Portland Cement Association Fellowship at the National Bureau of Standards, and the investigations of Woods, Stark, and Steinour of

the Riverside Cement Co. (*ENR* Oct. 6, 1932, p. 404, and Oct. 13, 1932, p. 435). Bogue's hypothesis, that cement is completely crystallized into certain clinker minerals in proportions calculated from the oxide analysis, permitted the properties and effects of the several components to be evaluated from a study of data obtained on a large number of cements carefully prepared to cover a wide range of composition. Although more recent researches on the constitution of portland cement qualify Bogue's work to some extent, it cannot be denied that the original theory offered a definite and invaluable groundwork for the study of special cements for mass concrete construction on the basis of chemical composition.

While the probable influence of "glass" on clinker composition was recognized, it was not considered practical at the time.

A complete review of the various investigations which had for their purpose the development of a cement of low-heat evolution is obviously beyond the scope of this paper. It is perhaps sufficient to summarize briefly the principal findings which resulted from the investigations conducted at the research laboratory of the Riverside Cement Co., the engineering materials laborary of the University of California, the National Bureau of Standards, and the Denver laboratories of the Bureau of Reclamation. For extended and complete data on the subject and an excellent bibliography, reference should be made to "Special Cements for Mass Concrete", a paper by J. L. Savage, chief designing engineer, U. S. Bureau of Reclamation, for the Second Congress of the International Commission on Large Dams, World Power Conference.

A considerable portion of this information is also included in articles by Steele and Blanks in *Engineering News-Record* of December 21, 1933, p. 737, and Nov. 22, 1934, p. 648.

Results of the research

The principal findings that relate to the design of low-heat cements are summarized as follows:

(a) Cements having low-heat characteristics and other desirable properties for mass concrete construction could be obtained through controlled chemical composition without any particular difficulty in their manufacture.

(b) A consistent relationship was found between the computed compound composition and both heat of hydration and compressive strength. With the aid of factors, derived from experimental data, it was found possible to predict the heat of hydration and compressive strength of a portland cement at any age with a fair degree of accuracy.

(c) Reduction in heat evolution at all ages was obtained by decreasing the C_3A (tricalcium aluminate) with a consequent increase in C_4AF (tetracalcium alumino-ferrite). When the C_3S (tricalcium silicate) was decreased and consequently the C_2S (dicalcium silicate) increased, a large reduction in heat of hydration was obtained at early ages and a moderate reduction at later ages.

(d) At all ages up to one year C_3A contributed approximately twice as much heat as did C_3S, and C_3S, in turn, contributed more heat than C_2S and C_4AF.

(e) The heat of hydration was decreased approximately 5 cal. per gr. for each one per cent increase in loss on ignition and increased, on the average, 2 cal. at 28 days and 1 cal. at 1 year for an increase in surface area of approximately 100 sq. cm. per gr.

(f) The early strength of portland cement was largely attributable to C_3S. Cements high in this compound developed a large portion of their 1-yr. strength during the first month. The increase in strength after one month was largely due to C_2S. Cements high in this compound showed less early strength but more prolonged strength development than cements high in C_3S. These two silicates contributed about equally to the ultimate strength. The effect of C_3A was, in general, to increase the strength somewhat at 7 and 28 days, but at the later ages to be detrimental. The C_4AF had little effect on compressive strength; in general, it lowered the strength slightly at all ages.

(g) An increase in fineness resulted in a material increase in strength, particularly at early ages and also at later ages. Under conditions of mass (sealed, adiabatic) curing, the percentage of increase in strength at one year was approximately one-half of the percentage increase in surface area. For moist curing at 70 deg. F., the percentage increase in strength was almost equal to the percentage increase in surface area.

(h) Higher fineness in cements of the same composition was found to result in increased rates of heat evolution during the early periods of hydration, although the total ultimate heat was only slightly increased.

(i) Higher fineness in cements of the same composition was found to increase the concrete workability, reduce the amount of water required in a mix, reduce water gain or bleeding, increase strength and heat of hydration at all ages (although the latter effect is less pronounced with time), decrease permeability, increase slightly the amount of water required for normal consistency and shorten slightly the time of set.

(j) No relation was found to exist between compound composition and plastic flow, Young's modulus and length changes of mortar bars under various conditions of storage. Lower moduli were, however, observed for low-heat cement concretes during early ages than for concretes made with standard cement.

(k) Low-heat cements were found to be slightly less resistant to the action of freezing and thawing, yet far superior to normal cements in resistance to aggressive (sulfate-bearing) waters.

(l) The effect of heat treatment of cement clinker (that is passing it through a second kiln either before or after cooling) was found, in general, to slightly reduce the heat of hydration; to decrease the compressive strength in many cases, dependent on the method of treatment and the composition of the clinker; to improve, in general, the grindability of the clinker; and to have little effect on durability. Heat treated clinker has not been used in commercial production.

As a result of the above investigations, it was found feasible to draft specifications for a special brand of portland cement having more desirable properties for use in mass concrete than those displayed by the standard product then employed. These specifications were carefully reviewed and approved by a board of consulting engineers on cement and concrete problems. (*ENR* Nov. 10, 1932, p. 558).

The average chemical and physical

PHYSICAL AND CHEMICAL PROPERTIES OF VARIOUS TYPE PORTLAND CEMENTS

Type of Cement	Number of Cements	Chemical Analysis — Percent								Computed Compound Composition — Percent								Fineness		
		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Ign. loss	Insol. res.	C_3S	C_2S	C_3A	C_4AF	$CaSO_4$	Free CaO	MgO	Ign. loss	Per cent passing 200 mesh	Per cent passing 325 mesh	(1) sq. cm. per gr.
High early str.	12	19.6	6.2	2.5	64.6	2.6	2.3	1.9	0.6	56	15	12	8	3.9	1.3	2.6	1.9	96.5	92.4	2,030
Standard	11	21.8	6.1	2.7	64.2	2.4	1.7	1.2	0.2	43	31	12	8	2.8	0.8	2.4	1.2	94.4	84.6	1,770
Modified	12	21.6	5.3	4.6	62.9	3.1	1.7	1.1	0.2	42	30	6	14	2.9	0.6	3.1	1.1	96.1	88.1	1,930
Low heat	14	23.5	5.1	4.7	60.5	3.0	1.8	1.1	0.2	20	52	6	14	3.1	0.3	3.0	1.1	94.9	86.2	1,930

Type of Cement	Number of Cements	Heat of Hydration — Cal. per Gram (2)								Temperature Rise — Deg. F.					Physical Properties			
		1 da.	3 da.	7 da.	14 da.	28 da.	3 mo.	6 mo.	1 yr.	1 da.	3 da.	7 da.	14 da.	28 da.	Initial set hr.-min.	Final set hr.-min.	Sp. gr.	Normal consistency
High early str.	12	76.2	101.8	108.3	111.0	113.7	116.2			55.2	72.5	76.9	78.7	80.5	3-10	5-30	....	25.3
Standard	11	50.4	78.6	86.0	89.1	90.7	95.2	98.0	99.7	37.1	56.9	62.0	64.1	65.2	3-35	5-40	3.15	24.1
Modified	12	41.0	62.6	73.9	78.6	81.6	87.3	90.6	92.2	30.5	45.9	53.8	57.1	59.1	3-40	5-30	3.19	23.4
Low heat	14	27.1	44.1	52.2	58.8	65.2	76.9	80.8	84.1	20.3	32.6	38.4	43.1	47.6	3-00	5-20	3.16	22.7

Type of Cement	Number of Cements	Compressive Strength — Lb. per Sq. In. Standard Curing (3)								Compressive Strength — Lb. per Sq. In. Mass Curing (5)							
		Average of 2" x 4", 3" x 6", and 6" x 12" Cylinders					Mass Conc.—28 Day			Average of 2" x 4", 3" x 6", and 6" x 12" Cylinders					Mass Conc.—28 Day		
		3 da.	7 da.	28 da.	90 da.	1 yr.	18" x 36" 6" max. agg.	6" x 12" 1½" max. agg.	(4) ratio	3 da.	7 da.	28 da.	90 da.	1 yr.	18" x 36" 6" max. agg.	6" x 12" 1½" max. agg.	(4) ratio
High early str.	12	3,250	4,380	5,480	6,180	6,580	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Standard	11	2,070	3,190	4,460	5,010	5,550	3,710	4,170	0.89	3,240	3,950	4,520	4,580	4,970	3,640	4,400	0.83
Modified	12	2,060	2,940	4,430	5,420	5,770	4,120	4,760	0.87	2,660	3,720	4,910	5,060	5,350	4,620	4,870	0.95
Low heat	14	890	1,590	3,390	4,880	5,640	2,870	3,300	0.86	1,420	2,400	4,210	4,480	5,040	3,510	4,460	0.79

[1] Surface area determined by Wagner turbidimeter. [2] Temperature rise and heats of hydration determined from adiabatically cured concrete, using Boulder Dam aggregate. [3] Concrete strengths obtained using Boulder Dam aggregate. [4] Ratio of 18" x 36" to 6" x 12" concrete strength. [5] Mass-cured specimens cured adiabatically 28 days, thereafter at 70 degrees F. Mix proportions by weight: 18" x 36" specimens, 1:2.45:7.05; 6" x 12" specimens, 1:2.44:3.30; 3" x 6" specimens, 1:2.45:2.75; 2" x 4" specimens, 1:2.90.

properties of low-heat cement are given in the accompanying table, together with average data on other type cements used in engineering practice in this country. A cross comparison of the characteristics of low-heat cement with the other types involved demonstrates that the principle of making this cement hinges on reducing C_3A and C_3S, together with finer grinding to restore strength lost at early ages through low C_3S content. In effect, this results in lowering of the hydraulic modulus or lime ratio and, in general, the addition of iron oxide in some form within calculated limits.

Nature of low-heat cement

The most important characteristic of low-heat cement, and the prime reason for its inception and use, is indicated by its name. About one-third less heat is generated on hydration than ordinarily results from standard portland cement, and high temperatures in mass concrete may, therefore, be almost proportionately reduced by its use. The rates of heat liberation are, however, different from standard portland cement in that heat is generated much more slowly and over a longer period of time, making its net value in the reduction of concrete temperatures dependent to some extent on the shape and size of the mass as well as the speed of construction.

The use and limitations of low-heat cement should be understood before employing it, and its adaptation for a particular job should be first determined, considering the structural designs, construction schedule and thermal properties of the concrete and conditions as a whole. Low early-strength, during the winter season, may under some conditions necessitate construction procedures, such as form removal, which differ from the ordinary. Since strength development is not as rapid as with other type cements, a more prolonged curing period is desirable for concrete made with low-heat cement. This is of less importance in regions with high relative humidity compared to the arid and semiarid regions of the west, where diligent curing is required to develop all the quality in portland-cement concrete. No concern need be given, however, for the strength of interior mass concrete made with low-heat cement, as this will at later ages equal if not exceed that of standard cement, particularly during seasons promoting high initial concrete temperatures. The permeability of concrete made with low-heat cement has been shown by some laboratory tests to be slightly less than that containing standard cement.

Recent laboratory studies corrobate field observations that low-heat cement concrete possess superior resistance to cracking. Speciments, with various cements, were subjected to first compressive and later tensile loads so as to hold them to constant length while undergoing mass curing and subsequent cooling. On cooling, and considerably before again reaching the initial temperature at which the concretes were mixed, those made with standard and modified cements were unable to resist the tension to which they were subjecting themselves, while the low-heat cement concrete permitted itself to be cooled some 20 deg. F. lower and sustained 30 per cent greater tensile stress before breaking.

It is concluded, therefore, that low-heat cement concrete is better able, through favorable plastic flow or extensibility characteristics, to adjust itself to temperature strains occurring during its early history, and that low-heat cement is for this reason better adapted for use in mass concrete.

Modified cement

Although it is not the purpose of this paper to discuss other types of

cement, some attention is directed to modified cement since it was evolved from the research and experiences with low-heat, being an effort to improve or "modify" the standard cement where it is considered most deficient. Modified cements, as will be noted from the table, differ, in general, from low heat in that the C_3S content or lime: silica ratio is higher. Modified, or "all purpose" cements have some of the more desirable characteristics of low-heat cement while retaining initial strengths equal to the standard product. Modified cement is now fast replacing standard cement in construction work undertaken by the Bureau of Reclamation, and has been used on several mass concrete jobs.

In cases where resort is not had to artificial cooling, final internal concrete temperatures may be as high with low-heat cement as with modified, due to the fact that the latter has a greater early rate of heat production, and therefore a greater proportion of heat is lost from the concrete before it is covered by a succeeding lift. Low-heat cement, on the other hand, possesses decided advantage in connection with artificial cooling, this combination permitting maximum internal temperatures to be reduced. For construction of the low Grand Coulee Dam, modified cement was employed even though the concrete was cooled, as it was concluded that an advantage already existed in that about 10 degrees lower average initial concrete temperatures would be secured. Compared with low heat, modified cement has, however, not been as successful in reducing temperature cracks, although it is observed to be an improvement over standard cement.

Use of low-heat cement

Morris Dam. Low-heat cement was first used in the construction of Morris Dam for the city of Pasadena, which was begun a year prior to Boulder Dam, and in which 570,000 barrels were employed. At that time considerable information was available from the uncompleted researches on cements for Boulder Dam, and on the basis of this the first low-heat specifications were formulated. Reports on the experiences with this cement at Morris Dam were satisfactory, with expressed opinions that less cracking occurred than on other similar structures. At first the cement was accepted with a fineness of 85 per cent passing the No. 200 sieve but, on account of noticeable water gain, this requirement was increased to 92 per cent. Most recent inspection of concrete work in this dam indicates an excellent condition, which authorities have attributed both to painstaking workmanship and to the type of cement employed.

Rodriguez Dam. During the early construction work on Rodriguez Dam, near Tijuana, Mexico, a coarse ground (85 per cent passing the No. 200 sieve) standard cement was tried in an attempt to alleviate cracking that was being experienced with standard cement ground to 92 per cent passing the No. 200 sieve. This did not, however, result in any material improvement. Later, some 100,000 barrels of low-heat cement, identical to that being supplied for Morris Dam, was used, and was found very successful in overcoming the objectionable cracking.

Boulder Dam. Construction of Boulder Dam was started before investigations on low-heat cement were completed and before this special cement was available. Some mass concrete in the dam was, therefore, placed with standard portland cement, as a result of which a direct comparison of low-heat cement under identical field conditions was possible.

From experiences and observations made on the job, it was concluded that the use of low-heat cement resulted in concrete more free from cracks than generally obtained with the standard cement. Where cracking did occur, it was of a minor nature and to a great extent can be associated with shrinkage from drying. No serious or extensive cracks have been noted in close surveys regularly made every three months, and it is quite certain that there are none which continue for any distance in the main body of the dam, such as have been noted in other structures.

The conclusion was also reached that concrete made with low-heat cement was more workable and required less water for the same slump, due principally to higher fineness. Since laboratory data and field experience had shown that the low-heat cement acquired strength slowly in concrete cast with low-initial temperature, it was considered desirable to blend low-heat with normal cement (proportions of 60–40) during the winter months, in order to expedite form removal and to insure more secure form anchorages in relatively green concrete. There were also other reasons, concerned with design, which prompted the use of this blend. The mean annual temperature at Boulder Dam is 72 deg. F., the highest mean maximum monthly being 108 deg. F. (in July), and the lowest mean minimum monthly 39 deg. F. (in January).

Other Bureau Dams. Low-heat cement is also being used in the Bartlett, Parker, and Marshall Ford dams. Bartlett Dam is a multiple-arch dam with hollow buttresses, in places 7 ft. thick, for which studies on heat flow and dissipation showed considerably lower resultant maximum temperatures with the use of low-heat than with modified cement. Parker and Marshall Ford dams are massive structures, both in regions with hot climates where initial concrete temperatures are high. Cooling was employed at Parker Dam, as at Boulder Dam. Observations with low-heat and modified cements at Bartlett Dam again substantiate the definite conclusion that the former type has superior resistance to cracking.

Mention has already been made of the increased fineness requirement for low-heat cement, due principally to the inherently low initial strengths which are obtained. This higher fineness also aids the early production of heat by increasing the rate of heat evolution, a desirable effect inasmuch as some of the heat may then be liberated from the concrete before it is covered by the following lift. In addition to increasing early strength it should be again repeated that increased workability, greater freedom from bleeding and reduced water requirements are also obtained with cements of relatively high fineness. A very recent experience of this Bureau was the use of a relatively coarse-ground standard cement in concrete repair work at Arrowrock Dam. Pronounced bleeding difficulties were experienced on the job and were remedied by increasing the cement fineness from about 1,450 to 2,000 sq. cm. per gr. surface area. The same effects were experienced during the construction of Morris Dam for the city of Pasadena, as has already been mentioned.

The raw materials used at five of the eight plants producing low-heat

cement clinker cover a rather wide range, each individual plant using no less than three different materials. Limestone, high-lime, and high-silica cement rock, ferruginous shale, siliceous tuff, granite diorite, quartzite, and sandstone are used for the basic mix, while hematite or iron pyrites are used for the iron addition at all plants, with but one exception. At two of the plants where pyrites were first employed, a change to hematite was made due to the high resulting SO_3 content of the clinker. The kilns used for burning the clinker ranged from as small units as 8 x 100 ft. to 11 x 275 ft., the largest. The output of these kilns for low-heat clinker was reported by two plants to have been increased 8 and 15 per cent, respectively; by two other plants no increase was noted; and by the last plant a lower output was claimed. At all plants, a lower temperature of burning and reduced fuel consumption for low-heat clinker as compared to the standard was experienced, with the exception of one plant which claimed the same temperature of burning and fuel consumption. Difficulties in burning the low-heat clinker were encountered at several plants until lower burning temperatures were employed and exceptionally large clinker and kiln rings were avoided.

In grinding clinker for finished cement, all plants reported a reduction in output for low-heat cement of from 10 to 40 per cent, three plants reporting a one-third reduction. In general, it was the opinion of those concerned that this reduction was due both to the increased fineness requirement and to the hardness of the clinker. This increased resistance to grinding of clinker of low-heat composition is also substantiated by laboratory tests using a small ball mill. The development of the proper burning technique in some instances resulted in clinker which was less difficult to grind.

Organization

Materials testing and concrete-control work are conducted in the Denver laboratories under the general supervision of Arthur Ruettgers, senior engineer, and under the immediate direction of R. F. Blanks, engineer. All research and design work is under the direction of J. L. Savage, chief designing engineer. All engineering and construction is under the general direction of R. F. Walter, chief engineer, with headquarters in Denver. All activities of the Bureau are supervised by John C. Page, commissioner of reclamation, Washington, D. C.

Water Meters in Indianapolis

W. W. DeBerard

Associate Editor, *Engineering News-Record*

All water is measured by meters which are selected for accuracy and longevity and kept in apple-pie order, especially for low flows

An article on the Indianapolis waterworks appearing in ENR *Sept. 8, p. 302 related to efficiency as represented by good standard practices, purification and distribution. In this issue the test, selection and maintenance of water meters are discussed.* —EDITOR

IT IS OF PRIME IMPORTANCE in selling a commodity to keep the scales, the yardstick, or the measuring tool in good condition. The 76,000 water meters which the Indianapolis Water Co. owns, installs and maintains are its prime instrumentalities of efficiency, and in consequence are probably given more careful attention than any other item in this closely cared-for system.

Indianapolis is underlaid with water-bearing soil and some 80 private wells provide an unknown quantity of water. By the old-fashioned salt content test for pollution the wells in the more congested areas show the effects of leakage of sewage into the ground water but there is little evidence of sickness. Several wells show more than 100 p.p.m. of chlorides in the heart of the city. Wells in the surrounding country show 0 to 25 p.p.m. Health boards have never required that connections be made to the public water system and in consequence the company maintains a constant water-selling campaign.

TABLE I—DISTRIBUTION OF TOTAL WATER PUMPED FOR SIX YEARS, 1932 TO 1937, INCLUSIVE

	Aver.	Max.	Min.
Registration of meters	82 6	86 6	82 6
Distribution system use	0 6	1 0	0 2
Distribution system leakage	2 9	3 1	2 6
City use (est.)	2 0	2 0	2 0
Meter under-registration (est.)	6 0	6 0	6 0
Unaccounted for	3 9	6 3	1 5
Total unmetered	15 3	17 4	13 4

Distribution system leakage is based on 100 gal. per day for each inch-mile of main and hydrant branch plus 2½ gal. per day for each live service.

Distribution system use includes bleeding, flushing, reservoir cleaning and new main flushing.

Meter under-registration is estimated from experience gained in testing. In 1937 3,936 of the 76,000 meters were given a complete test and 21,490 were given preliminary tests.

Present consumption, based on the amount of water pumped, is 75 gal. per capita per day, and for the company to prosper it is essential that as much as possible of the water pumped be registered on the meter dials which are read monthly. Much literature of a constructive character on the various factors involved in handling meters has come from the Indianapolis staff so that one's expectations are high of finding model procedures and methods.

First to be noted is the low figure of 5 per cent of unaccounted-for water. Customer meters register 85 per cent of the water pumped and 10 per cent is accounted for through water used by the city in extinguishing fires and in street and sewer flushing, and by the company in distribution system flushing, in under-registration of meters and in normal leakage in the distribution system. The above figures are for the

Fig. 1. Testing 15 meters at a time. Recording registers are removed and 1-ft. indicating dials are substituted during tests

Fig. 2. Meter repair bench with stock bins for parts in background

TABLE II — WEIGHED ACCURACIES OF FOUR ⅝-IN. METERS ON TOILET FLOWS (TOILET FLUSHED TWENTY TIMES IN 24-HR. PERIOD)

	Accuracies by Streams in Per Cent						Weighed Accuracy on Toilet Flow
G.P.M.	8.0	3.0	0.7	0.17	0.035	0.01	
Meter A	101.5	102.0	101.5	100.0	102.0	100.0	99.2
Meter C	100.0	100.0	93.0	73.0	30.0	0.0	91.7
Meter X	104.0	105.0	105.0	90.0	83.0	50.0	100.3
Meter Y	101.0	102.5	100.0	90.0	58.0	0.0	97.9

current year. Averages for the past six years are shown in Table I. In an effort to reduce the percentage of unaccounted-for water, a new leak detector is being used to find unusual losses in the distribution system.

H. W. Niemeyer, assistant engineer in charge of the meter shop, feels that unregistered low flows through meters deserve special attention. In consequence he has concentrated on that problem. It's a sorry day for a meter salesman who expects him to accept a meter that will not register at least 90 per cent of a 50-gal. per day stream after it has been "broken in." (AWWA specifications allow 2 per cent variation for 1 gal. per min. and 10 per cent for a new meter at ¼ gal. per min., a rate that supplies a fair percentage of the water for domestic purposes.) One meter company apparently has met these requirements and rumor has it that another one is soon to come out with a new meter having similar exceptional low-flow accuracy.

Leakage through plumbing

That practically no plumbing is bottle-tight has been proved time and again at Indianapolis. The ordinary toilet will leak from 1 to 50 gal. per day and still appear to have an absolutely tight shutoff. Tests made with a rate-of-flow recorder used in conjunction with a special meter on the premises of seven waterworks employees who are leak conscious and considered their plumbing tight showed leaks ranging from 1 to 15 gal. per day. Again, tests in the shops with a sensitive meter on a flush toilet in excellent repair with a specially devised attachment on a recording mechanism indicated an almost indefinite time before the pen would return to the zero flow position.

Graphs traced by recording meters in apartments, schools and public buildings have long been utilized to inform customers of water-use habits and to determine the proper size of meter to install. Coincidence of demand is much less than most people realize. The graphs prove it. It is surprising to find in a single family house what a small portion of the flow is as high as 10 gal. per min. The bulk of domestic use is at a rate under 5 gal. per minute.

In Fig. 5 is given the result of tests on the accuracies at different rates of 155 meters of five makes after passing 100,000 cu. ft. The percentage of use at the various rates Mr. Niemeyer estimated, but his estimate agrees substantially with intensive studies in New England in 1918 and 1933.

An actual demonstration of low-flow under-registration is noted in the following average for 13 monthly tests and comparative registration of two $\frac{5}{8}$-in. meters of different standard makes placed on the company-shop building service:

ACCURACY BY STREAMS

	$\frac{5}{8}$-in.	$\frac{1}{4}$-in.	$\frac{1}{16}$-in.	$\frac{1}{32}$-in.	Drips	Registration on Building Services cu. ft.
Meter A	100.0	100.5	99.0	95.8	80.0	28,181
Meter B	100.3	101.2	98.3	70.5	0.0	26,184
Diff.						1,997

In Meter B there is a 3 per cent drop-off between the maximum registration ($\frac{1}{8}$-in. stream) and the $\frac{1}{16}$-in. flow (internal inspection showed wear on the piston ball). While still within acceptable upper limits, its poor performance on initial flows caused a registration 7 per cent under Meter A. The comparison favored B, since A was new at the start of the comparison and B had already delivered 80,000 cu. ft. The building-up process had not been completed within A for after it had also delivered 80,000 cu. ft. it had developed an average accuracy of 101.0 per cent on the $\frac{1}{32}$ in. and 99.6 per cent on the drip streams (30 gal. per day) while only increasing to an average of 101.0 per cent on its maximum registration stream. Other comparative tests such as this have consistently indicated the importance of the low-flow accuracy not only for accurate measurement of actual service demands but also because the inherent weakness of any make of meter will first be reflected at the low end of the flow range.

These findings over a period of years, applied in a practical way to the various types of meters installed but more particularly to an older group of 56,000, have induced the meter department to set up a limiting accuracy standard of 3 per cent drop-off from the maximum registration point to the $\frac{1}{16}$-in. streams. This standard is considered too loose and will be tightened as the retirement program progresses and more accurate meters are installed.

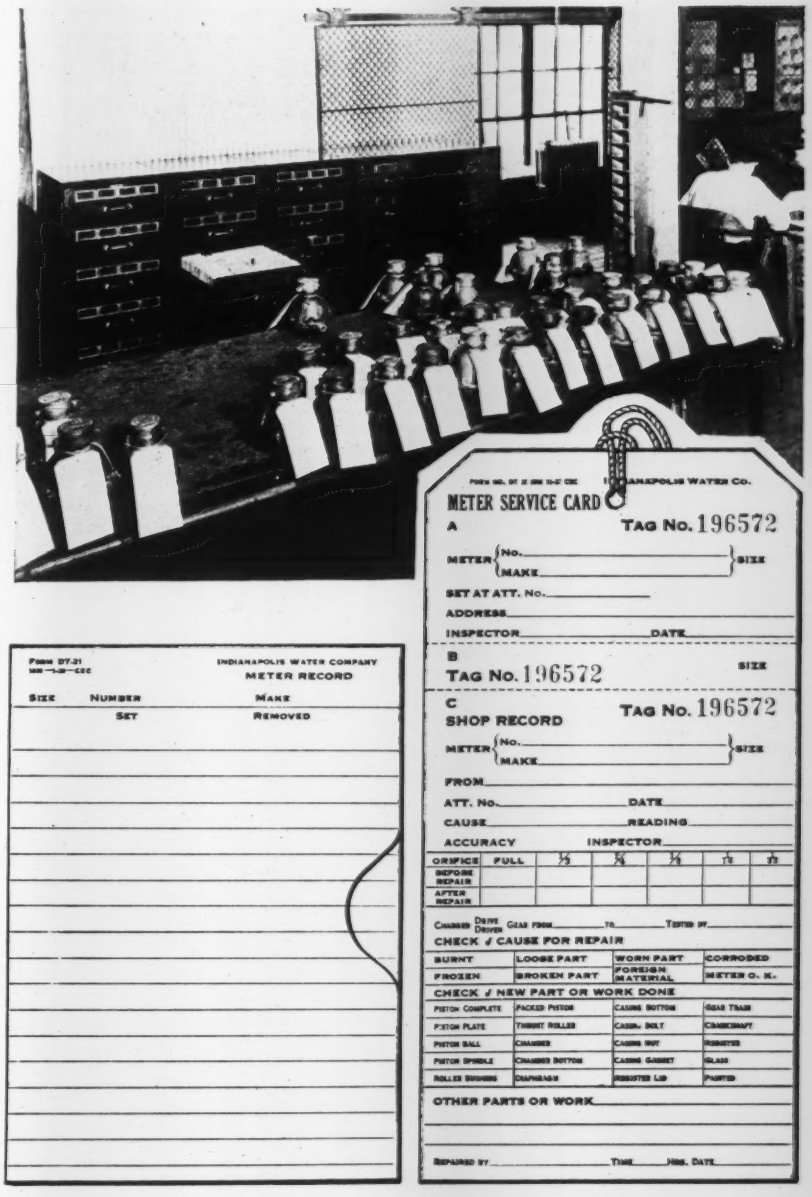


Fig. 3. Original records of tests are placed on tag cards which are removed from meters and filed in envelopes thus reducing record keeping clerical handling to a minimum and, below, envelope (a) and original meter test record (b).

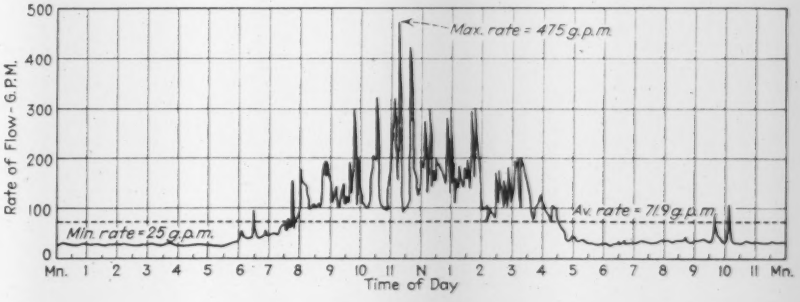

Max. rate = 475 g.p.m.
Av. rate = 719 g.p.m.
Min. rate = 25 g.p.m.
Rate of Flow - G.P.M.
500
400
300
200
100
0
Mn. 1 2 3 4 5 6 7 8 9 10 11 N 1 2 3 4 5 6 7 8 9 10 11 Mn.
Time of Day

Fig. 4. Demand study of high school using 103,239 gal. Attendance, 5,925; toilets, 219; urinals, 117; lavatories, 117; drinking fountains, 98.

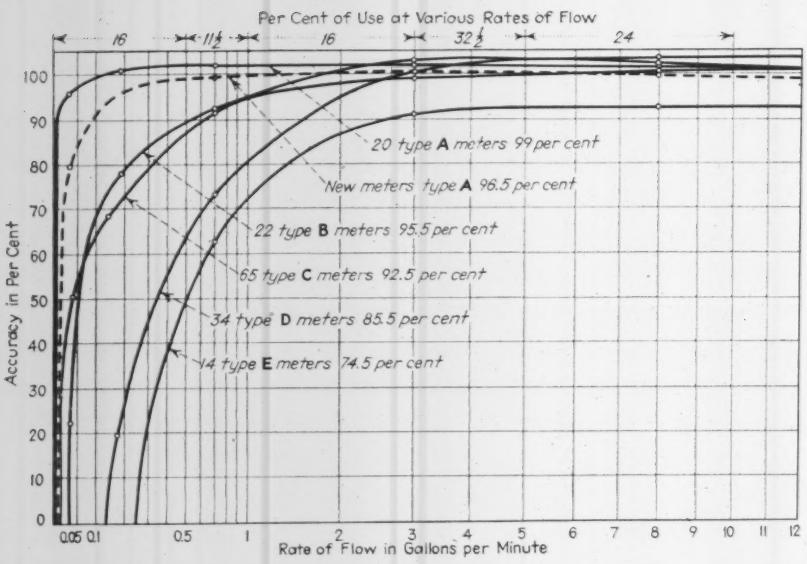


Fig. 5. Accuracies of 155 $\frac{5}{8}$-in. meters of four types based on average tests after passing 100,000 cu. ft.

Form No. DT 6 - 2M SAMPLE

SERVICE LINE RECORD

Indianapolis Water Company

For 3366 Euclid Avenue, Street

METER DATA

Size 5/8"
Type Conn. Straight-line
Type Pit
Size

Location Diagram

House

X

Walk

Curb

Meter Account No. K-831 Attachment No. 99330

Tap Measurement 93½' N. 2/FP. S. 34th - 20' E. W. Euclid

Box Measurement 93½' N. 2/FP. S. 34th - 3' E. W. Euclid

PIPE DATA

Location	Size	Material	Make	Length	Date Installed
Street	¾"	Copper	Mueller	20 feet	12/22/15
Yard	¾"	W. I.	Byers	50 feet	12/22/15

FITTING DATA

Fitting	Size	Make	Other Data
Tap	¾"	Mueller	
Curb Stop	¾"	Chase	Inverted
Stop and Waste Valve	¾"	Mueller	Street side of the meter

Remarks:

Fig. 6. Service line record.

Since 1930, small $\frac{5}{8}$-in. meters are brought in for complete test when the meter reader records a registration of 100,000 cu. ft. The quantity increases proportionately for larger sizes: $\frac{3}{4}$-in., 250,000; 1-in., 500,000; 1½-in., 750,000; 2-in., 1,000,000; 3-in., 3,000,000; 4-in., 5,000,000; 6-in., 10,000,000 cu. ft.

The "complete" test on the $\frac{5}{8}$-in. size, of which about 3,000 come in each year, involves (a) measurement of $\frac{5}{8}$-in., $\frac{1}{8}$-in., $\frac{1}{16}$-in. and $\frac{1}{32}$-in. streams, (b) repair of defective parts and (c) reset to zero. Meters removed on service disconnection orders, some 12,000 annually, are given a "preliminary" test on $\frac{1}{16}$-in. streams only. Meters checked on consumer's request are given a "complete test." If found within the 2 per cent tolerance the consumer pays a charge and the meter is replaced without resetting to zero. About 6,000 removal orders originate with the meter reader each year, who reports stoppages or other apparent defects in addition to the registration limits.

Retirement of meters

Retirement is dependent on a gain in revenue derived through the replacement as well as decreased maintenance. The company has found that it is a decided advantage to replace types having low-flow inaccuracies with superior types. Cost of parts per year for the less accurate type averaged 22 c. per meter owned over four years. If all meters were of that type it is estimated that the total meter maintenance cost would be $32,000 instead of the actual $16,000 in 1936. About 2,000 meters are retired each year. Retirement is made when the cost of repairs and parts exceeds 50 per cent of the original cost.

Meter handling

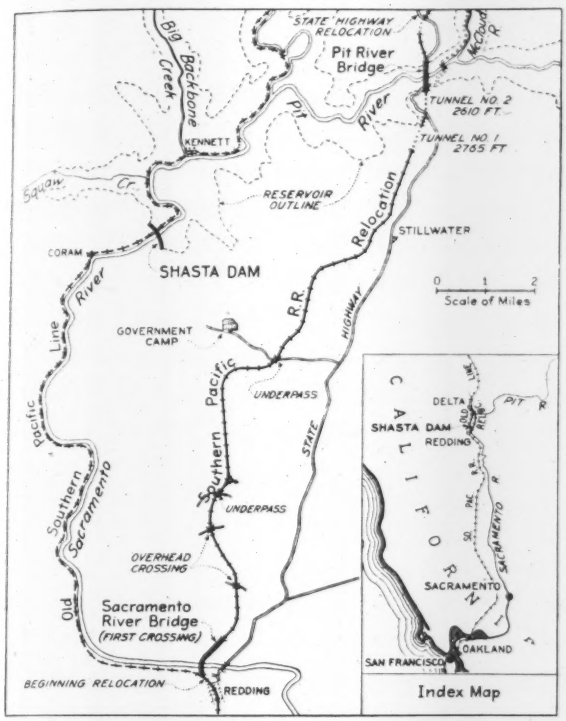
A meter history card filed by number is maintained. Especially novel is the filing of original service, maintenance and test records, which reduces the clerical work to a minimum. One man does the filing and also handles notice cards to the meter setters. These men have definite districts and take with them one-half day's quota of "sets" and "pulls" when leaving headquarters each morning and noon. At mid-morning and mid-afternoon they report by phone and are given advice of any inquiries, ordinarily called complaints elsewhere, and turn-ons that may have accrued during early morning or early afternoon. Thus consumers may get service on their demands within a few hours after they have advised the company office. This speed-up policy has brought much favorable comment. Emergency service is also given patrons within 24 hours.

The meter readers are specially trained in deportment, as they are often the only company representative the customer ever sees. They follow definite routes, laid out on large scale maps on which the location of each house is noted. There is no doubling back. Many owners provide the company with duplicate keys to their houses for use should no one be at home on the day that the meter is to be read. These keys are jealously guarded and identified by numbers available only to a limited personnel. "Sidewalk readings" are rare, and the last reader who tried it was reported by a customer whom he missed within 2 hours of his passing the premises.

H. S. Morse is general manager of the Indianapolis Water Co. and William C. Mabee is chief engineer. The meter shop is under the general supervision of C. W. Winkle, superintendent of distribution, with Mr. Niemeyer in direct charge.

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work



RAILROAD RELOCATION AROUND SHASTA DAM

OWNER: U. S. Bureau of Reclamation, R. F. Walter, chief engineer; Walker R. Young, construction engineer for the Central Valley project.

PROJECT: Earth work, tunnels and structures for part of Southern Pacific Railroad relocation around Shasta Dam, divided into five schedules totaling 14.05 mi. in length. Work includes two overpasses and two underpasses, two tunnels and a bridge across the Pit River. The Sacramento River bridge at Redding is not included in this contract. First overhead crossing is a 133-ft. three-span continuous I-beam bridge with concrete deck and footings in solid rock; second overhead crossing is a 100-ft. reinforced concrete three-span bridge. First underpass is a reinforced concrete rigid frame bridge of 23-ft. span, and second is a 33-ft. span rigid frame reinforced concrete bridge. The first tunnel, 2,765 ft. long, has a maximum height of 27-ft. and a width of 17-ft. 2,553 ft. of tunnel No. 2 has the same cross section as tunnel No. 1. The remaining 131 ft. is to be prepared for double track and will have a cross section 30 ft. high and 37 ft. wide.

CONDITIONS: Contractor is to begin work within 30 days of receipt of notice to proceed and is to complete work within 400 calendar days from this date. Liquidated damages are $100 per day for each uncompleted schedule. Government will furnish the following material: cement; admixtures, if required; coating materials for waterproofing concrete; reinforcements; clay sewer pipe and tar paper for permanent drains; and all other materials that will become a part of the completed contract, with a few exceptions, notably aggregates and other native materials. These materials will be delivered to the contractor f.o.b. cars at Redding, Calif. At all points where the railroad embankment extends below the proposed high water level of Shasta Reservoir, thoroughly compacted embankment will be required. Minimum labor rates are as follows: skilled $1.10 per hr.; semi-skilled, 90c. per hr.; common, 75c. per hr.

BIDS: Thirty-two different contractors bid on from one to five schedules. Five contractors bid on all five. In the following tabulation, bidding information on the individual schedules is given.

SCHEDULE I.

17 Bidders; High bid $295,354

LOW BIDDERS:

1. Granfield, Farrar and Carlin, San Francisco. $176,387
2. Jahn and Bressi Const. Co. Inc., and R. G. Clifford, Los Angeles..... 190,986
3. N. M. Ball Sons, Berkeley..... 191,990

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing right-of-way	41 acre	$70.00	$150.00	$175.00
2. Excav. common, roadway	417,000 c. y.	0.20	0.205	0.185
3. Excav. rock, roadway	115,000 c. y.	0.20	0.205	0.27
4. Overhaul	1,230,000 sta. yd.	0.003	0.005	0.004
5. Water for moist. embank mat	3,100 m. g.	1.00	1.20	1.40
6. Rolling embank	500 hr.	4.50	4.00	4.00
7. Excav. common, struct.	4,000 c. y.	0.75	0.80	0.90
8. Excav. rock, struct	1,000 c. y.	1.50	1.60	1.50
9. Conc. headwalls for pipe culverts and siphons	150 c. y.	18.00	28.00	22.00
10. Conc. box culverts	490 c. y.	12.00	18.00	15.00
11. Conc. arch culverts	1,420 c. y.	13.50	15.00	15.50
12. Conc. overhead crossings	450 c. y.	16.00	17.00	16.00
13. Placing reinf	279,500 lb.	0.02	0.017	0.02
14. Sp. finish. conc. surf	200 s. y.	0.50	0.50	0.45
15. Waterproofing conc	2,700 s. y.	0.30	0.10	0.20
16. Riprap	1,200 c. y.	1.50	2.20	2.50
17. Dry-rock paving	300 s. y.	2.00	1.50	1.40
18. Backfill	6,600 c. y.	0.35	0.20	0.30
19. Compact. backfill	5,500 c. y.	0.35	0.30	0.30
20. Lay. 18-in. C. M. P.	42 l. f.	0.35	0.30	0.40
21. Lay. 24-in. C. M. P.	110 l. f.	0.40	0.40	0.45
22. Lay. 30-in. C. M. P.	50 l. f.	0.50	0.50	0.60
23. Lay. 36-in. C. M. P.	36 l. f.	0.60	0.70	0.70
24. Lay. 42-in. C. M. P.	52 l. f.	0.75	0.80	0.80
25. Lay. 48-in. C. M. P.	180 l. f.	1.25	1.50	1.50
26. Lay. 54-in. C. M. P.	130 l. f.	1.50	2.00	2.50
27. Lay. 18-in. conc. pipe	36 l. f.	0.50	0.50	0.50
28. Lay. 24-in. conc. pipe	260 l. f.	0.60	0.70	0.60
29. Lay. 30-in. conc. pipe	90 l. f.	0.70	0.90	1.00
30. Lay. 36-in. conc. pipe	268 l. f.	0.80	1.00	1.00
31. 8-in. perf. pipe track drains	180 l. f.	0.40	1.00	1.00
32. Erecting struct. steel in overhead cross	122,000 lb.	0.02	0.02	0.025
33. Timber rail, overhead cross	5 M.b.m.	75.00	50.00	100.00
34. Install. misc. metalwork	1,000 lb.	0.05	0.09	0.04
35. Barbed-wire right-of-way fences	4 mi.	220.00	250.00	300.00
36. Woven-wire right-of-way fences	2 mi.	265.00	300.00	350.00
37. Install. right-of-way fence gates	4 ea.	10.00	12.00	10.00
38. Const. timber aprons, cattle guards	2 ea.	20.00	30.00	40.00
39. Const. auto. crossing	L.S.	50.00	60.00	50.00

SCHEDULE II.

18 Bidders; high bid $348,298

LOW BIDDERS:

1. Granfield, Farrar and Carlin, San Francisco. $216,592
2. Jahn and Bressi Const. Co. Inc., and R. G. Clifford, Los Angeles..... 217,679
3. Frederickson and Westbrook, Sacramento.... 224,111

(Contract Unit Prices continued on following page)

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clear. right-of-way	50 acre	$100.00	$170.00	$150.00
2. Excav. common, roadway	136,300 c. y.	0.36	0.32	0.31
3. Excav. rock, roadway	226,500 c. y.	0.36	0.32	0.31
4. Overhaul	1,360,000 sta. yd.	0.003	0.005	0.004
5. Water for moist. embank. mat	3,400 m. g.	0.80	1.20	0.75
6. Rolling embank	500 hr.	4.50	4.00	3.50
7. Excav. common, struct	4,100 c. y.	0.75	0.80	1.00
8. Excav. rock, struct	2,900 c. y.	1.50	2.00	1.75
9. Conc. headwalls for pipe culverts and siphons	265 c. y.	18.00	26.00	30.00
10. Conc. box culverts	1,180 c. y.	12.50	18.00	18.00
11. Conc. arch culverts	770 c. y.	14.00	15.00	18.00
12. Conc. underpasses	790 c. y.	14.00	15.00	18.00
13. Placing reinf	416,000 lb.	0.02	0.017	0.01
14. Sp. finish. conc. surf	340 s. y.	0.50	0.50	2.75
15. Water proofing conc	4,700 s. y.	0.30	0.10	0.17
16. Riprap	900 c. y.	1.50	2.20	3.00
17. Dry-rock paving	450 s. y.	2.00	2.00	1.15
18. Backfill	8,500 c. y.	0.35	0.20	0.90
19. Compacting backfill	7,500 c. y.	0.35	0.40	0.50
20. Lay 24-in. C. M. P	50 l. f.	0.40	0.40	0.20
21. Lay 30-in. C. M. P	548 l. f.	0.50	0.50	0.25
22. Lay 36-in. C. M. P	50 l. f.	0.60	0.70	0.30
23. Lay 48-in. C. M. P	314 l. f.	1.25	1.50	1.50
24. Lay 60-in. C. M. P	258 l. f.	1.50	2.00	2.00
25. Lay 24-in. conc. pipe	434 l. f.	0.60	0.70	0.70
26. Lay 30-in. conc. pipe	486 l. f.	0.70	0.90	1.00
27. Lay 36-in. conc. pipe	438 l. f.	0.80	1.00	1.50
28. Const. 8-in. perf. pipe track drains	252 l. f.	0.40	1.00	0.40
29. Install. 4-in. sewer-pipe drains in walls of underpasses	400 l. f.	0.60	0.20	0.50
30. Erect. timber in underpasses and highway bridge	4 M.b.m.	40.00	40.00	70.00
31. Install. misc. metalwork	1,700 lb.	0.07	0.09	0.40
32. Const. barbed-wire right-of-way fences	6 mi.	220.00	250.00	230.00
33. Const. woven-wire right-of-way fences	3 mi.	265.00	300.00	275.00
34. Install. right-of-way fence gates	8 ea.	10.00	12.00	20.00
35. Constr. timber aprons, cattle guards	6 ea.	20.00	30.00	60.00
36. Constr. auto. crossings	6 ea.	50.00	60.00	125.00

SCHEDULE III.

18 Bidders; High bid $345,865

LOW BIDDERS:

1. Heafy-Moore Co. and Fredrickson and Watson Const. Co., Oakland $184,518
2. Bates and Rogers, Oakland 204,771
3. Granfield, Farrar and Carlin, San Francisco .. 206,425

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing right-of-way	32 acre	$106.00	$106.00	$100.00
2. Excav. common, roadway	42,300 c. y.	0.375	0.41	0.47
3. Excav. rock, roadway	297,800 c. y.	0.375	0.41	0.47
4. Overhaul	1,641,000 sta. yd.	0.004	0.0053	0.004
5. Water for moist. embank. mat	3,100 m. g.	1.50	1.05	0.60
6. Rolling embank	500 hr.	5.00	4.25	3.00
7. Excav. common, struct	1,100 c. y.	1.22	1.05	.075
8. Excav. rock, struct	1,100 c. y.	1.22	3.20	1.50
9. Conc. in headwalls for pipe culverts and siphons	75 c. y.	16.00	17.50	18.00
10. Conc., box culverts	1,380 c. y.	16.00	18.20	12.50
11. Placing reinf	199,200 lb.	0.016	0.018	0.02
12. Special finishing of conc. surf	50 s. y.	0.60	1.22	0.50
13. Waterproofing conc. surf	2,600 s. y.	0.13	0.21	0.30
14. Riprap	1,000 c. y.	2.00	3.20	1.50
15. Dry-rock paving	250 s. y.	3.90	3.20	2.00
16. Backfill	4,700 c. y.	0.60	0.40	0.35
17. Compact. backfill	4,600 c. y.	0.35	0.70	0.40
18. Lay 24-in. C. M. P	50 l. f.	0.57	0.41	0.40
19. Lay 30-in. C. M. P	50 l. f.	0.70	0.53	0.50
20. Lay 36-in. C. M. P	36 l. f.	0.72	0.80	0.60
21. Lay 60-in. C. M. P	38 l. f.	1.45	2.00	1.50
22. Lay 24-in. conc. pipe	40 l. f.	1.00	0.53	0.60
23. Lay 30-in. conc. pipe	116 l. f.	1.30	1.10	0.70
24. Lay 36-in. conc. pipe	256 l. f.	1.35	1.60	0.80
25. Const. 8-in. perf. pipe track drains	216 l. f.	0.50	0.53	0.40
26. Const. barbed-wire right-of-way fences	3 mi.	352.00	415.00	250.00
27. Const. woven-wire right-of-way fences	2 mi.	375.00	510.00	280.00
28. Install. right-of-way fence gates	6 ea.	12.00	14.00	10.00
29. Const. timber aprons, cattle guards	2 ea.	30.00	14.00	20.00
30. Constr. auto. crossing	L.S.	48.00	56.00	50.00

SCHEDULE IV.

19 Bidders; high bid, $371,728

LOW BIDDERS:

1. Heafy-Moore Co. and Frederickson and Watson Const. Co. Oakland $187,616
2. Bates and Rogers Const. Corp. Oakland 200,338
3. Granfield, Farrar and Carlin, San Francisco .. 212,975

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clear. right-of-way	22 acre	$106.00	$106.00	$100.00
2. Excav. common, roadway	12,200 c. y.	0.375	0.41	0.49
3. Excav. rock, roadway	312,200 c. y.	0.375	0.41	0.49
4. Overhaul	3,347,000 sta. yd.	0.004	0.0053	0.004
5. Water for moist. embank. mat	3,300 m. g.	1.50	1.05	0.50
6. Rolling embank	500 hr.	5.00	4.25	3.00
7. Excav. common, struct	1,100 c. y.	1.22	1.05	0.75
8. Excav. rock, struct	1,100 c. y.	1.22	3.20	2.00
9. Conc. in headwalls for pipe culverts and siphons	100 c. y.	16.00	17.00	18.00
10. Conc. in box culverts	430 c. y.	16.00	18.00	14.00
11. Conc. in arch culverts	1,040 c. y.	16.00	14.50	14.00
12. Placing reinf	159,500 lb.	0.016	0.018	0.02
13. Sp. finishing conc. surf	50 s. y.	0.60	1.22	0.50
14. Waterproofing conc. surf	2,100 s. y.	0.13	0.21	0.30
15. Riprap	400 c. y.	2.00	3.20	1.50
16. Dry-rock paving	300 s. y.	3.90	3.20	2.00
17. Backfill	3,900 c. y.	0.60	0.40	0.35
18. Compacting backfill	3,700 c. y.	0.35	0.70	0.40
19. Laying 24-in. C. M. P	48 l. f.	0.57	0.41	0.40
20. Laying 30-in. C. M. P	50 l. f.	0.70	0.53	0.50
21. Laying 36-in. C. M. P	50 l. f.	0.72	0.80	0.60
22. Laying 48-in. C. M. P	430 l. f.	1.15	1.06	1.25
23. Laying 12-in. conc. pipe	40 l. f.	0.45	0.32	0.50
24. Laying 24-in. conc. pipe	126 l. f.	1.00	0.53	0.60
25. Laying 30-in. conc. pipe	82 l. f.	1.30	1.10	0.70
26. Laying 36-in. conc. pipe	126 l. f.	1.35	1.60	0.80
27. Const. 8-in. perforated-pipe track drains	216 l. f.	0.50	0.53	0.40
28. Const. barbed-wire right-of-way fences	2.5 mi.	352.00	415.00	250.00
29. Const. woven-wire right-of-way fences	1.0 mi.	375.00	410.00	280.00
30. Install. right-of-way fence gates	4 ea.	12.00	14.00	10.00
31. Const. timber aprons, cattle guards	2 ea.	30.00	14.00	20.00
32. Const. auto. crossing	L.S.	48.00	56.00	50.00

SCHEDULE V.

16 Bidders; high bid, $1,299,721

LOW BIDDERS:

1. West Construction Co., Monrovia, Calif. $904,981
2. Winston Bros. Co., Los Angeles 955,204
3. MacDonald and Kahn, San Francisco 992,428

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing right-of-way	8 acre	$100.00	$120.00	$200.00
2. Excav. common, roadway	1,10 c. y.	0.60	0.95	1.00
3. Excav. rock, roadway	55,000 c. y.	0.85	0.95	1.00
4. Overhaul	1,000 sta. yd.	0.02	0.01	0.02
5. Water for moist. embank. mat	500 m. g.	2.00	0.35	2.00
6. Rolling embank	100 hr.	5.00	5.00	10.00
7. Excav. common, struct	450 c. y.	1.00	1.75	2.00
8. Excav. rock, struct	550 c. y.	2.50	4.00	4.00
9. Excav. all classes, tunnels	110,700 c. y.	5.15	5.10	5.00
10. Permanent steel tunnel supports	638,100 lb.	0.07	0.09	0.08
11. Permanent timbering in tunnels	113 M.b.m.	75.00	60.00	92.00
12. Const. 8-in. longitudinal tunnel drains	1,000 l. f.	1.00	2.70	3.00
13. Install. metal drain and weep pipes, tunnels	50,000 lb.	0.025	0.04	0.10
14. Drill, weep holes, tunnels	3,200 l. f.	0.60	0.60	1.00
15. Conc. tunnel lining, except in inverts	24,250 c. y.	7.00	8.65	9.80
16. Conc. tunnel inverts	1,020 c. y.	8.50	7.30	13.00
17. Conc. tunnel portals	1,400 c. y.	8.00	11.00	16.00
18. Conc. headwalls for pipe culverts and siphons	40 c. y.	20.00	20.00	18.50
19. Conc. box culverts	250 c. y.	20.00	19.00	18.00
20. Placing reinf	1,519,000 lb.	0.015	0.01	0.01
21. Sp. finish. conc. surf	600 s. y.	1.00	0.75	1.15
22. Waterproofing conc. surf	500 s. y.	0.50	0.20	0.50
23. Riprap	100 c. y.	2.00	0.75	5.00
24. Dry-rock paving	350 s. y.	2.00	2.25	3.00
25. Backfill	1,500 c. y.	0.50	0.50	1.00
26. Compact. backfill	900 c. y.	0.60	0.75	0.50
27. Laying 30-in. C. M. P	50 l. f.	1.00	1.00	1.00
28. Laying 36-in. C. M. P	50 l. f.	1.50	1.30	1.00
29. Laying 30-in. conc. pipe	86 l. f.	1.50	1.80	1.50
30. Laying 36-in. conc. pipe	342 l. f.	2.00	2.25	1.50
31. Const. 8-in. perf. pipe track drains	36 l. f.	1.00	3.00	2.50
32. Install. elect. conduits, tunnels	22,800 l. f.	0.05	0.10	0.09
33. Install. misc. metalwork	1,000 lb.	0.10	0.10	0.10
34. Const. barbed-wire right-of-way fences	2 mi.	600.00	550.00	500.00
35. Const. woven-wire right-of-way fences	1 mi.	800.00	600.00	800.00
36. Install. right-of-way fence gates	2 ea.	25.00	20.00	25.00
37. Const. timber aprons, cattle guards	2 ea.	50.00	25.00	75.00
38. Const. auto. crossing	L.S.	100.00	100.00	50.00